

**National Institute of Standards and Technology  
Advanced Radiometer (NISTAR) User's Guide**

**September 9, 2015**



National Aeronautics and

**Goddard Space Flight Center  
Greenbelt, Maryland**

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## Preface

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This document was written for the DSCOVER Flight Operations Team (FOT) and is intended to collect information together in one source for clarifying NISTAR operations and functionality.

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## 1.0 INTRODUCTION

### 1.1 OVERVIEW

The National Institute of Standards and Technology Advanced Radiometer (NISTAR) is a science instrument mounted on the Deep Space Climate Observatory (DSCOVER) spacecraft. NISTAR will monitor the reflected solar and emitted infrared light from Earth.

DSCOVER is a two-year spaceflight mission with enough consumables on-board for an additional three years. The revised primary operations objective of the DSCOVER mission is to provide solar wind thermal plasma and magnetic field measurements to enable space weather forecasting by the National Oceanic and Atmospheric Administration (NOAA).

Secondary science objectives are to image the Sun lit disk of Earth in 10 spectral bands with a spatial resolution of 12 kilometer (km) or better, to determine ozone, aerosol, cloud cover, cloud height, vegetation, and leaf area indices and to measure the Earth reflected irradiance in the wavelength range of 0.2 - 100 microns.

DSCOVER mission will travel to Lagrange-1, or L1 (the neutral gravity point between the Sun and the Earth - 1.5 million kilometers from Earth) to provide early warning of approaching solar storms, at this location it will have a continuous view of the sun and the sunlit side of the Earth.

The DSCOVER Mission utilizes the Triana Flight hardware, which had been placed in clean stable storage after that program was cancelled in 2003. The Triana program is named after Rodrigo de Triana, the lookout who first saw the New World from Columbus' ship.

The purpose of the National Institute of Standards and Technology Advanced Radiometer (NISTAR) User's Guide is to provide a collection of currently available NISTAR operations and functionality related information in a single document.

### 1.2 SCOPE

This document provides detailed information on NISTAR science objectives, instrument structure, instrument flight software and operations information. The information presented on operations refers to operation of the instrument in the Integration and Test (I&T) environment and also to operations on-orbit. Any differences between I&T development and on-orbit operations, will be noted.

Detailed information on how the instrument works to measure the optical power entering the instrument already exists as part of another document and will not be repeated here. It is recommended that the Scripps-NISTAR Instrument Development and Performance Specification (Revision Date: April 16, 1999, written by Steven Lorentz, Joe Rice, and Tim Jung, Optical Technology Division, NIST, Gaithersburg, MD 20899), be read before this one.





### 1.3 DOCUMENT STRUCTURE

This document includes four sections. The following paragraphs give a brief description of each section:

- Section 1: The Introduction describes the purpose and scope of this document and provides the structure for the rest of the document. It also provides a reference list and an overview.
- Section 2: The Science Objectives section provides a brief synopsis of the NISTAR science objectives.
- Section 3: The Instrument Description provides detailed information on all parts of the instrument structure, flight software, and provides power and thermal information.
- Section 4: The NISTAR Operations section describes in detail the power-on and off procedures for the instrument. It also includes information on the on-board scripts that are used to safe the instrument. Configuration monitors that are to be used while NISTAR is powered are listed and explained as well as on-orbit calibration operations.

### 1.4 REFERENCE DOCUMENTATION

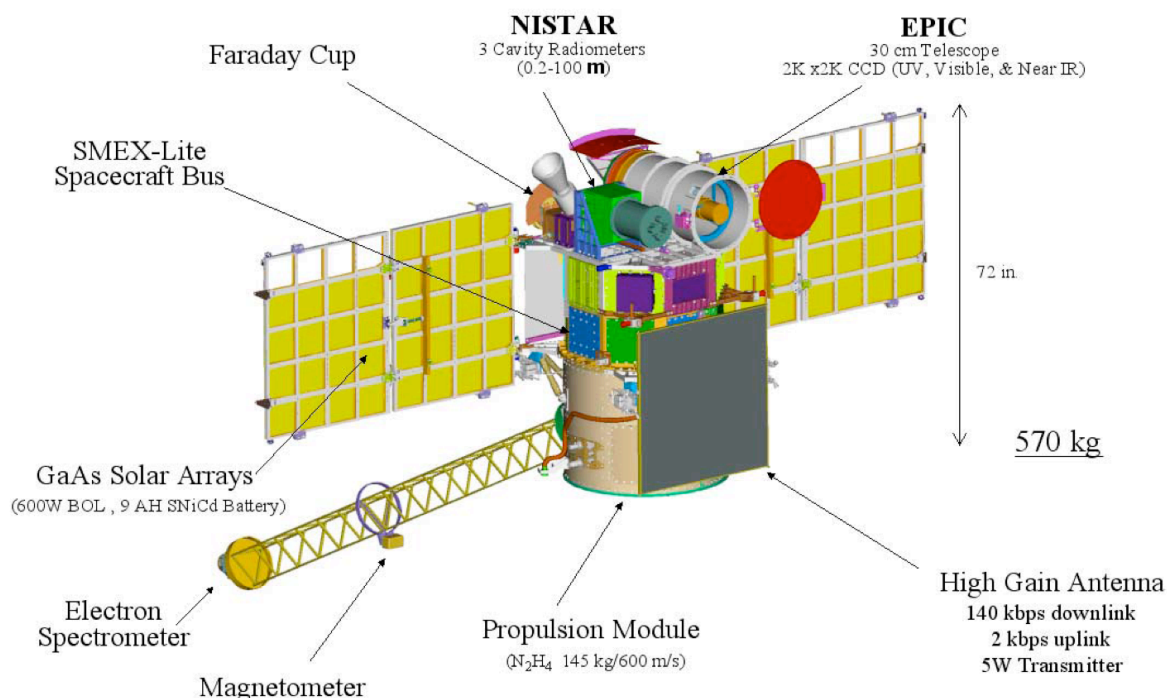
The documents listed below are used as references for the development of these concepts. Refer to these documents to support, further define, and clarify the information in the NISTAR User's Guide.

1. DSCOVER Memo/Redlines & Triana 1553 Data Bus Implementation Document, DSCOVER-ICD-000136 (Alt ID#: TRIANA-ICD-013), July 21, 2000, Revision 7.
2. Scripps-NISTAR Flight Software Detailed Design Review Presentation, Dave Hughes, Phil Inslee, Tomas Ryan, Ball Aerospace and Technologies Corp., October 22, 1999.
3. Scripps-NISTAR Instrument Development and Performance Specification, Steven Lorentz, Joe Rice, and Tim Jung, Optical Technology Division National Institute of Standards and Technology, Gaithersburg, MD 20899, Revision Date: April 16, 1999.
4. NISTAR Mission Operations, S.R. Lorentz, National Institute of Standards and Technology, June 9, 2000.
5. NISTAR Flight Software Interface Control Document Section 1 – 1553 and Section 2 – QHSS, Phil Inslee, Tomas Ryan, Ball Aerospace and Technologies Corp., Revision G, June 20, 2001.
6. Integrated Test and Operations System User's Guide, at <http://itos.gsfc.nasa.gov/ITOS/>.
7. DSCOVER Integrated Test and Operations System Telemetry and Command Volume II, at <http://columbus.gsfc.nasa.gov/~DSCOVER/tcvol2/>.



## 2.0 SCIENCE OBJECTIVES

The DSCOVR primary science objectives is to continue solar wind measurements in support of space weather requirements providing 3-dimensional distribution function of the proton and alpha components of the solar wind; 3-dimensional magnetic field vector and 3-dimensional electron velocity distribution. Secondary objective is to observe the Earth from the unique Earth-Sun L1 perspective. Tertiary objective is to measure the energetic particle environment.



**Figure 2-1. DSCOVR Observatory**

NISTAR will measure the Earth's energy balance (the solar input minus the Earth reflection and radiation to space) to improve our understanding of the effects of changes caused by human activities and natural phenomena. NISTAR will provide the first direct measurements of the radiant power reflected by the full Earth disk with a goal of 0.1% accuracy. NISTAR will make simultaneous measurements in three bands.

- Band-A (0.2 to 100μ) - visible plus far infrared channel to measure total radiant power coming from the Earth
- Band-B (0.2 to 4μ) - solar channel to measure reflected solar radiation
- Band-C (0.7 to 4μ) - near infrared channel to measure reflected infrared solar radiation

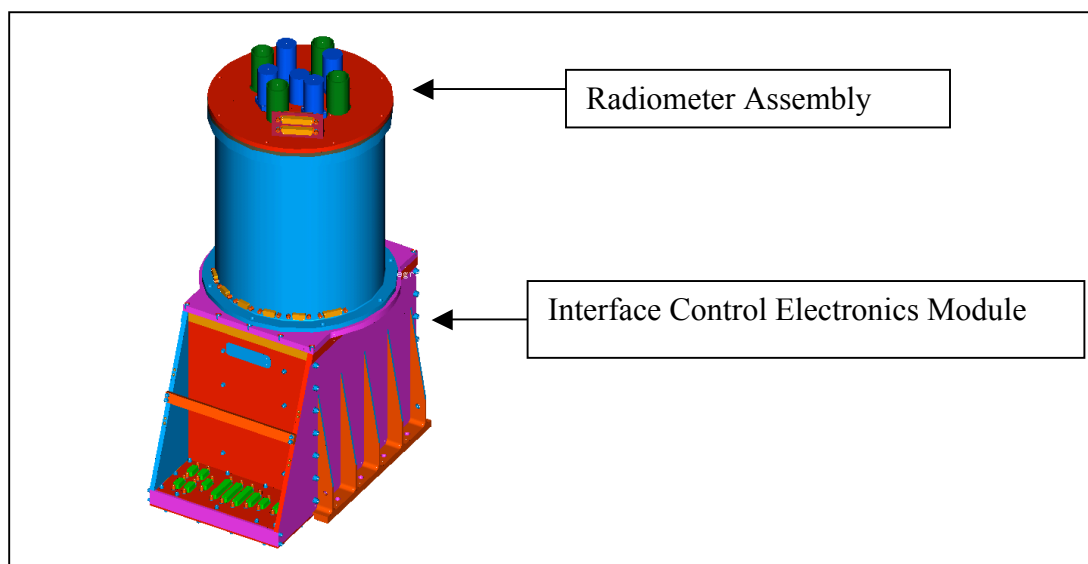


### 3.0 INSTRUMENT DESCRIPTION

#### 3.1 NISTAR STRUCTURAL DESCRIPTION

NISTAR, pictured in Figure 3-1, consists of the Radiometer Assembly (RA) and the Interface and Control Electronics (ICE) module. The RA houses three electrical substitution radiometers with separate optical shutter/contamination doors for each, a silicon photodiode (SiPD, also abbreviated as PD or SD throughout this document) filter detector ( $0.3$  to  $1\mu$ ) which is used as a calibration reference for the radiometers, a heat sink (HS), and a twelve position filter wheel (FW). The ICE consists of a RAD6000 processor, motor driver, MIL-STD-1553 interface, and housekeeping electronics.

NISTAR has a radiometer Field of View (FOV) of  $1^\circ$  and Field of Regard (FOR) of  $7.0^\circ$ . The FOR is important to note such that the NISTAR boresight must be  $7^\circ$  away from a light source so no light from that light source will enter the instrument. NISTAR will be aligned with the Earth Polychromatic Imaging Camera (EPIC) camera boresight, another scientific instrument mounted on the DSCOVN observatory.

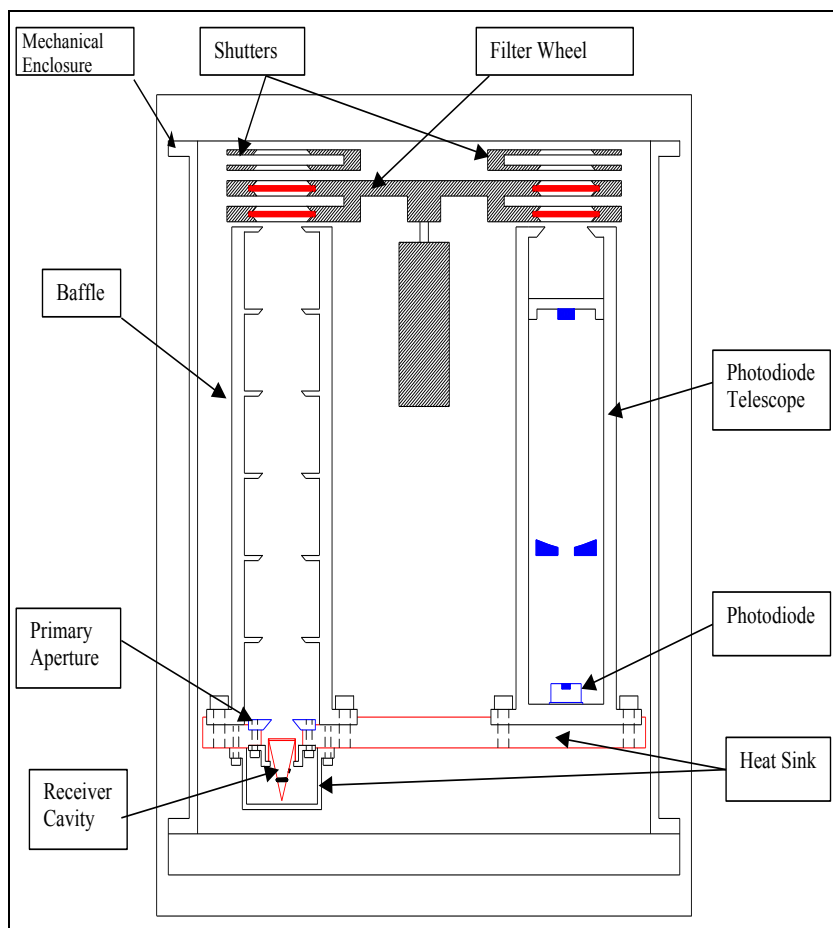


**Figure 3-1. NISTAR Structural Diagram**

##### 3.1.1 Radiometer Assembly Overview

The RA depicted in Figure 3-2 consists of three receiver cavities that are mechanically supported from a surrounding HS. The receivers are shaped into a cavity for enhanced absorption. Three precision apertures are mounted on the HS directly in front of each of the three receiver cavities. The Photodiode Assembly, which consists of the photodiode telescope and photodiode, is also mechanically supported from the HS. The mechanical enclosure for the receiver cavities, photodiode, and heat sink consists of the basic mechanical structure, four shutters and one filter wheel (including motors, drivers, limit detectors and associated electronics).





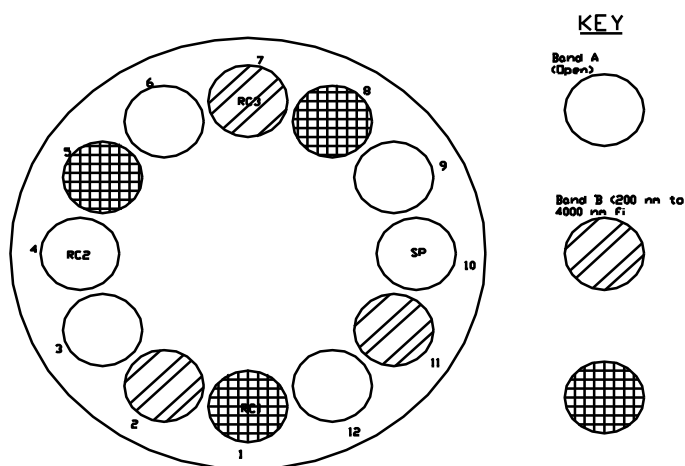
**Figure 3-2. Radiometer Cross Section**

The differential temperature between the Receiver Cavities (RC) and the HS is actively controlled at a fixed operating point by an electronic servo loop. Also, the HS is actively temperature controlled at a fixed absolute temperature by a separate electronic servo loop. The optical power entering the cavity when the shutter is opened is measured by monitoring the drop in applied electrical heater power required to maintain the RCs at a fixed operating point.

#### 3.1.1.1 Filter Wheel

The filter wheel is a dual level wheel with twelve optical positions numbered 1 through 12 each capable of holding two filters in series. The filters are 25 millimeters (mm) in diameter and are made of fused silica with multi-layer coatings. There are a total of six locations with filters (three each for Band-B and Band-C), and six locations that are open (Band-A) as illustrated in Figure 3-2. Typically, the filter transmission in space will degrade with exposure. Ultraviolet radiation, oxygen or outgassing contaminants will change the filter. Having multiple filters for each band and using one of the filters in each band 99% of the time and then switching to the others for short periods of time will allow degradation of the filters to be tracked.





**Figure 3-3. Filter Wheel Position Diagram**

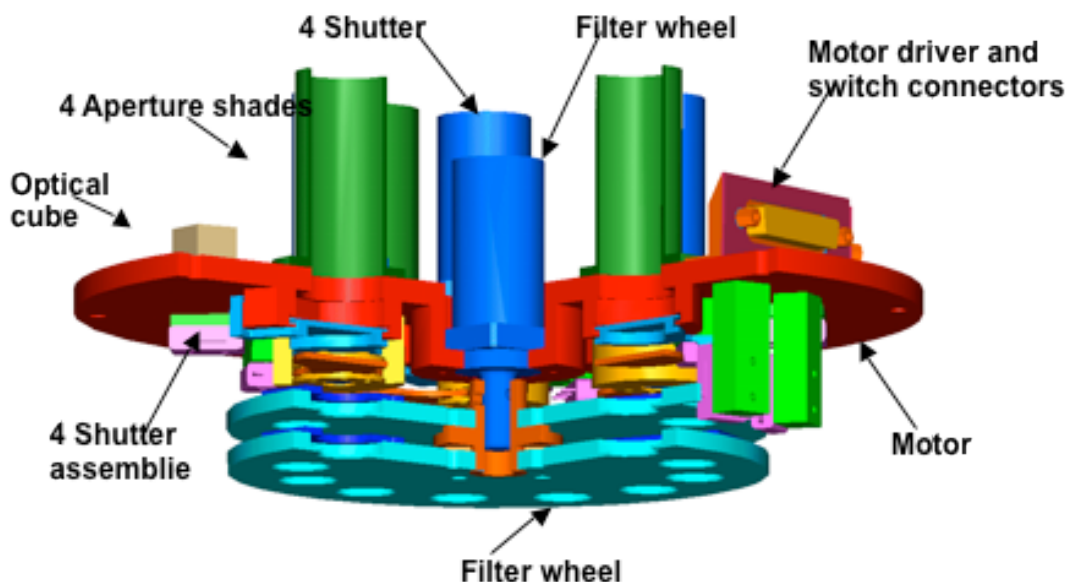
Table 3-1 is a key that correlates the filter wheel position number (read in telemetry mnemonic NIPREFWPOSNUM) to the positions of the various filters over each cavity. The normal position for the wheel is at a filter wheel step number of 3.

**Table 3-1. Filter Wheel Position Key**

| <b>Filter Position versus Filter Wheel Motor Position Number</b> |                 |     |     |     |     |      |      |
|------------------------------------------------------------------|-----------------|-----|-----|-----|-----|------|------|
|                                                                  | <u>FW Steps</u> | 3   | 102 | 202 | 302 | 402  | 502  |
| <u>Detector</u>                                                  |                 |     |     |     |     |      |      |
| RC1                                                              | 1C              | 12A | 11B | 10A | 9A  | 8C   |      |
| RC2                                                              | 4A              | 3A  | 2B  | 1C  | 12A | 11B  |      |
| RC3                                                              | 7B              | 6A  | 5C  | 4A  | 3A  | 2B   |      |
| Photodiode                                                       | 10A             | 9A  | 8C  | 7B  | 6A  | 5C   |      |
|                                                                  | <u>FW Steps</u> | 602 | 702 | 802 | 902 | 1002 | 1101 |
| <u>Detector</u>                                                  |                 |     |     |     |     |      |      |
| RC1                                                              | 7B              | 6A  | 5C  | 4A  | 3A  | 2B   |      |
| RC2                                                              | 10A             | 9A  | 8C  | 7B  | 6A  | 5C   |      |
| RC3                                                              | 1C              | 12A | 11B | 10A | 9A  | 8C   |      |
| Photodiode                                                       | 4A              | 3A  | 2B  | 1C  | 12A | 11B  |      |
| {Code: xy, where x=wheel location (1-12), y= filter band (A-C)}  |                 |     |     |     |     |      |      |



The filter wheel has two mechanical limits detectors located at positions 0 and 1103. These are in place to keep the filter wheel from being able to make more than one revolution in either direction. If the filter wheel is moved so that the limit detector is hit during its motion, the filter wheel will be re-calibrated automatically and will return to position 3 if the "closed" (position 0) limit switch was hit or it will be returned to position 1101 if the "open" (position 1103) limit switch was hit. The limit detectors have a lifetime limit of 25,000 hits.



**Figure 3-4. Filter Wheel and shutter Assembly**

The filter wheel can be calibrated by command. This calibration allows the software to determine and track the filter wheel's position by step number. The calibration is accomplished in the following manner:

- The normal boot-up calibration state for the filter wheel is uncalibrated (NIFWCAL = "UNCALIBRATED".)
- When the command is sent to calibrate the filter wheel, the filter wheel is moved and the calibration state changes to "WAITING CAL CMD", which means the software has received the calibration command and is waiting for the filter wheel to hit the close position limit switch.
- The calibration state then changes to "UNCAL WAIT SWITCH", which means the software has started the calibration procedure and is waiting for the filter wheel to hit the closed limit switch.
- When the close limit switch has been hit the filter wheel is stopped and the calibration state changes to "HALTING CLOSED."
- After the limit switch is hit, the filter wheel is backed off the limit switch a few positions and the calibration state changes to "BACKING OFF CLOSE."
- The software calibration state then changes again to "UNCAL WAIT SWITCH" while the filter wheel is moved to the open switch. The calibration state changes to "HALTING OPEN" when the open limit switch is hit.



- The filter wheel is then backed off the open limit switch (calibration state is then "BACKING OFF OPEN".)
- The filter wheel is then moved to position 3 and the calibration state is set to "CALIBRATED".
- If at any time during the calibration procedure the limit switches aren't hit when the software expects the calibration state will be set to "SWITCH FAIL OPEN" or "SWITCH FAIL CLOSE" based on which switch was supposed to be hit.

Note that the calibration process is fairly quick and not all calibration states may be seen in telemetry.

The telemetry associated with the filter wheel position and calibration is listed in Table 3-2.

**Table 3-2. Filter Wheel Telemetry**

| <b>Mnemonic</b>                                  | <b>Description</b>                                                                                                                                                                                                                                          |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIFWCAL – FW Calibration State                   | Reports the filter wheel calibration status. Possible values are:<br>UNCALIBRATED<br>WAITING CAL CMD<br>SWITCH FAIL OPEN<br>SWITCH FAIL CLOSE<br>BACKING OFF OPEN<br>BACKING OFF CLOSE<br>HALTING OPEN<br>HALTING CLOSED<br>CALIBRATED<br>UNCAL WAIT SWITCH |
| NIFWCCWSC – FW Counter Clock-wise Switch Counter | Reports the number of times the filter wheel has hit the limit detector located in the counter clock-wise or "closed" position.                                                                                                                             |
| NIFWCWSC - FW Clock-wise Switch Counter          | Reports the number of times the filter wheel has hit the limit detector located in the clock-wise or "open" position.                                                                                                                                       |
| NIPREFWPOSNUM – FW Predicted Position Number     | Reports what the software thinks the filter wheel step position is.                                                                                                                                                                                         |

There are three commands associated with the filter wheel. They are described below.

**NIMVWHEEL** – This command physically moves the filter wheel to the selected step position. Valid positions are 0 – 1103. This command can only be sent if the flight software is in Science mode.

**NIFWCAL** – This command starts the calibration of the filter wheel. After the calibration is completed the filter wheel will be at step 3. The command can be sent in any software mode.





NIINTWHLPOS – This command sets the filter wheel step position to any selected position from 0 –1103. This command does not actually move the filter wheel to that step position. It just fools the software into thinking that the filter wheel is at the commanded step position. The Built-In-Test (BIT) status of the filter wheel (telemetry mnemonic NIFWBIT) must be "PASS" in order for the software to accept this command. The BIT will be "FAIL" if the filter wheel has not been calibrated. See Sections 3.1.2.18 and 3.1.2.1.9.4 for more on BIT. This command will not likely be used on-orbit. It is used during I&T to test the limit switch detectors. This command can only be sent in Science mode.

More on the filter wheel is presented in Section 3.1.2.1.9.4.

### 3.1.1.2 Shutters

Mechanical shutters are located at the top of each RC and the PD to prevent contamination.

Each shutter has two mechanical limits detectors located at software shutter position numbers 0 and 200. These are in place to keep the shutters from moving too far into the mechanical enclosure. If a shutter is moved so that the limit detector is hit during its motion, the shutter will be re-calibrated automatically and will return to position 2 if the "closed" (position 0) limit switch was hit or it will be returned to position 198 if the "open" (position 200) limit switch was hit. The limit detectors have a lifetime limit of 25,000 hits.

Each shutter can be calibrated by command. This calibration allows the software to determine and track the shutter's position by step number. The calibration is accomplished in the following manner:

- The normal boot-up calibration state for the shutter is uncalibrated (NIRC1,2,3CAL = "UNCALIBRATED".)
- When the command is sent to calibrate the shutter, the shutter is moved and the calibration state changes to "WAITING CAL CMD", which means the software has received the calibration command and is waiting for the shutter to hit the close position limit switch.
- The calibration state then changes to "UNCAL WAIT SWITCH", which means the software has started the calibration procedure and is waiting for the shutter to hit the closed limit switch.
- When the close limit switch has been hit the shutter is stopped and the calibration state changes to "HALTING CLOSED."
- After the limit switch is hit, the shutter is backed off the limit switch a few positions and the calibration state changes to "BACKING OFF CLOSE."
- The software calibration state then changes again to "UNCAL WAIT SWITCH" while the shutter is moved to the open switch. The calibration state changes to "HALTING OPEN" when the open limit switch is hit.
- The shutter is then backed off the open limit switch (calibrations state is then "BACKING OFF OPEN".)
- The shutter is then moved to position 2 and the calibration state is set to "CALIBRATED".





- If at any time during the calibration procedure the limit switches aren't hit when the software expects the calibration state will be set to "SWITCH FAIL OPEN" or "SWITCH FAIL CLOSE" based on which switch was supposed to be hit.

Note that the calibration process is fairly quick and not all calibration states may be seen in telemetry.

The NISTAR flight software has the ability to autocycle selected shutters. This autocycling opens and closes only the selected shutters at a selected period.

The telemetry associated with the shutter position, calibration and autocycling is listed in Table 3-3.

**Table 3-3. Shutter Telemetry**

| <b>Mnemonic</b>                                                                                                                                                                                                                                                                                                                                                  | <b>Description</b>                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIRC1CAL – RC1 Calibration State<br>NIRC2CAL – RC2 Calibration State<br>NIRC3CAL – RC3 Calibration State<br>NIPDCAL – Photodiode Calibration State                                                                                                                                                                                                               | Reports the shutter calibration status for the specified shutter. Possible values are:<br>UNCALIBRATED<br>WAITING CAL CMD<br>SWITCH FAIL OPEN<br>SWITCH FAIL CLOSE<br>BACKING OFF OPEN<br>BACKING OFF CLOSE<br>HALTING OPEN<br>HALTING CLOSED<br>CALIBRATED<br>UNCAL WAIT SWITCH |
| NIRC1SHTRCSC – RC1 Closed Switch Counter<br>NIRC1SHTROSC – RC1 Open Switch Counter<br>NIRC2SHTRCSC – RC2 Closed Switch Counter<br>NIRC2SHTROSC – RC2 Open Switch Counter<br>NIRC3SHTRCSC – RC3 Closed Switch Counter<br>NIRC3SHTROSC – RC3 Open Switch Counter<br>NIPDSHTRCSC – Photodiode Closed Switch Counter<br>NIPDSHTROSC – Photodiode Open Switch Counter | Reports the number of times shutter has hit the limit detector located in the specified (open or closed) position.                                                                                                                                                               |



| Mnemonic                                                                                                                                                                                                   | Description                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| NIRC1PRESHPOSNUM – RC1 Shutter Position Number<br>NIRC2PRESHPOSNUM – RC2 Shutter Position Number<br>NIRC3PRESHPOSNUM – RC3 Shutter Position Number<br>NIPDPRESHPOSNUM – Photodiode Shutter Position Number | Reports what the software thinks the specified shutter step position is.                          |
| NIAUTOCYCLE – Autocycle Status                                                                                                                                                                             | Reports whether the autocycle function is active or inactive. Possible values are "OFF" and "ON". |
| NIPDSHCYCLE – Photodiode shutter Cycle Status<br>NIRC1SHCYCLE – RC1 Shutter Cycle Status<br>NIRC2SHCYCLE – RC2 Shutter Cycle Status<br>NIRC3SHCYCLE – RC3 Shutter Cycle Status                             | Reports whether the specified shutter will be cycled when autocycling is commanded on.            |

There are six commands associated with the shutters. They are described below.

**NIMVSHUTTER** – This command physically moves the specified shutter to the selected step position. Valid positions are 0 – 200. This command can only be sent if the flight software is in Science mode.

**NIOPENSHUT** – This command moves the selected shutter to position 198. Position 198 is considered to be fully open. This command can only be sent if the flight software is in Science mode.

**NICLOSESHUT** – This command moves the selected shutter to position 2. Position 2 is considered to be fully closed. This command can only be sent if the flight software is in Science Mode.

**NISHUTTERCAL** – This command starts the calibration of the specified shutter. After the calibration is completed the shutter will be at step 2 (closed position). The command can be sent in any software mode.

**NIINTSHTRPOS** – This command sets the specified shutter step position to any selected position from 0 – 200. This command does not actually move the shutter to that step position. It fools the software into thinking that the shutter is at the commanded step position. The BIT status of the selected shutter (telemetry mnemonics NIPDSHTRBIT, NIRC1SHTRBIT, NIRC2SHTRBIT, NIRC3SHTRBIT) must be "PASS" in order for the software to accept this command. See Sections 3.1.2.1.8 and 3.1.2.1.9.3.

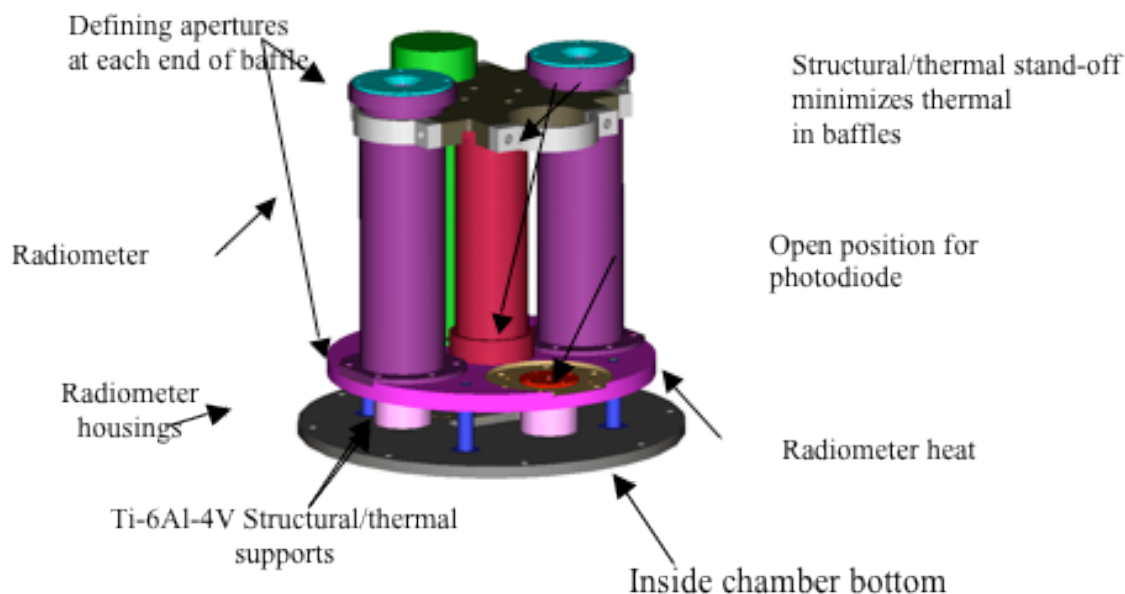
**NOTE:** This command will not likely be used on-orbit. It is used during I&T to test the limit switch detectors. This command can only be sent if the flight software is in Science mode.



**NIAUTOCYCLE** – This command turns on and off the automated shutter cycling. This command will start cycling the selected shutters open and closed for a selected period until commanded off by this command or until maintenance/safe mode is entered. The period is in seconds and ranges from 10 – 65535. For example, if a period of 300 seconds is selected all selected shutters will be opened for 150 seconds and then closed for 150 seconds. This motion will be repeated until the command to turn autocycling off is sent. All selected shutters will close (position 2) when cycling starts and when it is stopped. This command can only be sent if the flight software is in Science Mode.

Shutter position commands are rejected if another motor is currently running.

More on the shutters is presented in Section 3.1.2.1.9.3.



**Figure 3-5. Chamber Assembly Overview**

### **3.1.2 Interface and Control Electronics (ICE)**

The ICE consists of a motor driver, housekeeping electronics, and RAD6000 processor with a MIL-STD-1553 interface. It is powered by the +28 Volts (V) DSCOVN observatory power bus.

The motor driver controls the radiometers, the radiometer heat sink, the photodiode sensor, and filter wheel.



The housekeeping electronics has two analog channels. Analog #1 is used for radiometers 1 and 2 and the photodiode. Analog #2 is used for radiometer 3 and the radiometer heat sink. Temperature, voltage and mode monitors are housed in the ICE and RA to measure NISTAR's health, safety and status.

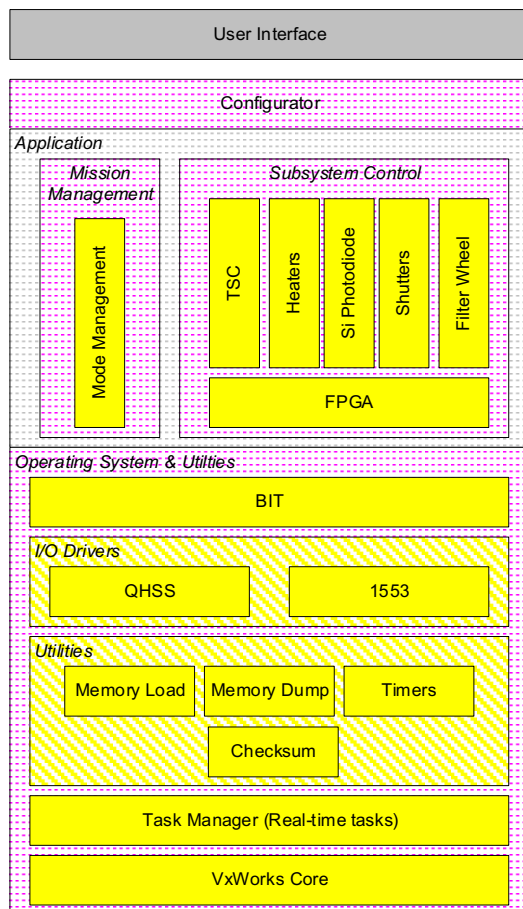
The RAD6000 processor consists of a Central Processing Unit (CPU) with 1Megabyte (MB) of Electrically Erasable Programmable Read-Only Memory (EEPROM), Start-up Read-Only Memory (ROM), 4MB of Static Read Access Memory (Static Read Access Memory [SRAM] or Read Access Memory [RAM]), and an input/output (I/O) card. A memory map can be seen in Appendix B. The processor runs the flight software, which controls and monitors the NISTAR instrument. The software includes the necessary thermal model to predict temperatures and the temperature/thermal flux temporal stability of the radiometers.

The I/O card is utilized as the (UART) interface and Quad High-Speed Serial (QHSS) interface connection. A 40Megahertz (MHz) oscillator and a 20MHz oscillator are included.

### 3.1.2.1 NISTAR Flight Software

The NISTAR flight software architecture consists of the operating system and utilities, a configurator module, an applications module that is made up of the mission management and subsystem control tasks and hardware interfaces. The dependency order is illustrated in Figure 3-4 with the VxWorks Operating System as the basis. Each element of the flight software architecture will be discussed in later sections.





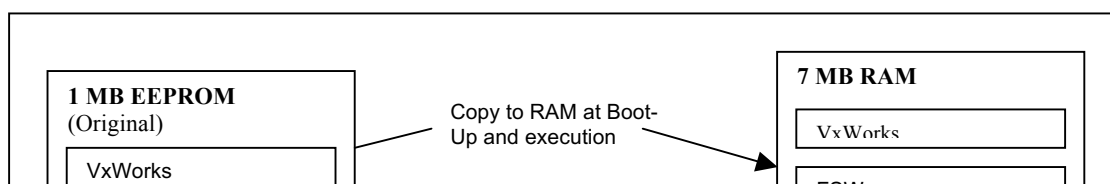
**Figure 3-6. NISTAR Flight Software Architecture**

There are two images of the flight software in EEPROM. The first image cannot be modified, called the Original version. The other image can be modified on the fly; this one is called the Modifiable version. This is illustrated in Figure 3-5.

At boot up, the VxWorks operating system and the Original version of the flight software are uploaded into RAM and executed. The original VxWorks kernel cannot be modified from the ground. It is possible to unload the Original version and load the Modifiable version, into RAM, without replacing VxWorks.

The Modifiable version of the FSW can be patched during normal operation with an EEPROM memory upload. The Original/Modifiable version of the FSW can be patched (in RAM only) during normal operation with a RAM memory upload.

A table can be uploaded into RAM or EEPROM from the ground.



### Figure 3-7. NISTAR Memory Configuration

#### 3.1.2.1.1 Operating System

The NISTAR flight software runs on the VxWorks operating system. The Operating System Built-In-Test Status Mnemonic provides the general health status of the flight processor. This can be seen in the NIOSBIT telemetry mnemonic and can be either "PASS" or "FAIL". The BIT will fail when the EEPROM and SRAM checksum validation fails. It also fails when the Error Detection and Correction hardware (EDAC) finds single and/or multi-bit errors. EDAC is discussed in Section 3.1.2.1.12.

#### 3.1.2.1.2 Task Manager

The Task Manager is responsible for managing the execution of each application. Each application must provide their execution priority, execution rate and scheduling mode to the Task Manager. The Task Manager is capable of running applications independently as part of their own thread. Since the Task Manager runs at a rate of 400Hertz (Hz), all applications can run at a maximum of 400Hz. Based on the application scheduling mode, the application can either run in the foreground mode, which will run registered applications in a fixed order, or background mode, which uses multi-tasking to run applications at known rates and priorities.

The Task Manager can provide the instrument time to all applications. The Task Manager can also report overruns for every registered task. Overruns are caused whenever EEPROM is written to.



This is because an EEPROM write has a very high priority and takes up a great deal of processor power leaving the rest of the tasks unattended. What task reports the overruns while EEPROM is written to depends on what the system was doing at the time of the EEPROM access; thus the reporting task is somewhat random. Since the operating system is true multitasking, it is possible to see overruns in most of the tasks, the probability of which is weighted by how often each task is run and how long they take. Telemetry mnemonics reporting the overrun statuses for each task are presented in Table 3-4.

**Table 3-4. Task Manager Overrun Telemetry**

| <b>Mnemonic</b>                                                                         | <b>Description</b>                                                                                                                                 |
|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| NIMMMDOR - Mission Manager Overrun Status                                               | Indicates whether or not an overrun has occurred for the Mission Manager Task. Possible values are "OCCURRED" or "NOT OCCURRED".                   |
| NISCFPGAOR - Subsystem Control (SC) Field Programmable Gate Array (FPGA) Overrun Status | Indicates whether or not an overrun has occurred for the FPGA Task. Possible values are "OCCURRED" or "NOT OCCURRED".                              |
| NISCFWOR - Subsystem Control Filter Wheel Status Overrun Status                         | Indicates whether or not an overrun has occurred for the SC FW Task. Possible values are "OCCURRED" or "NOT OCCURRED".                             |
| NISCHTROR - Subsystem Control Heaters Overrun Status Overrun Status                     | Indicates whether or not an overrun has occurred for the SC Heaters Task. Possible values are "OCCURRED" or "NOT OCCURRED".                        |
| NISCPDOR - Subsystem Control Silicon Photodiode Overrun Status                          | Indicates whether or not an overrun has occurred for the SC PD Task. Possible values are "OCCURRED" or "NOT OCCURRED".                             |
| NISCSHTROR - Subsystem Control Shutter Overrun Status                                   | Indicates whether or not an overrun has occurred for the SC Shutters Task. Possible values are "OCCURRED" or "NOT OCCURRED".                       |
| NISCTSCOR - Subsystem Control DSCOVN Spacecraft (TSC) Overrun Status                    | Indicates whether or not an overrun has occurred for the SC TSC Task. Possible values are "OCCURRED" or "NOT OCCURRED".                            |
| NITSKMGROR - Subsystem Control Task Manager Overrun Status                              | Indicates whether or not an overrun has occurred for the SC Task Manager Task. Possible values are "OCCURRED" or "NOT OCCURRED".                   |
| NITSKORID - Task Overrun Identification (ID)                                            | Reports the name of the task that has overruns. If more than one task has overruns, this telemetry will cycle through the ID numbers periodically. |



| <b>Mnemonic</b>                 | <b>Description</b>                                                                                     |
|---------------------------------|--------------------------------------------------------------------------------------------------------|
| NITSKORCNT - Task Overrun Count | Reports the number of overruns that have occurred in the task that is currently reported in NITSKORID. |

The following command will reset task overruns:

NICMDRESET – This command will reset the NISTAR command counters (telemetry mnemonics NICMDCNT and NIERRCNT) to 1 and 0 respectively. It will also set all overrun statuses to “NOT OCCURRED”. The task overrun ID and the task overrun count are not reset and may contain old values. Thus it is possible for the software to be reporting an overrun ID and overrun count for an overrun status that has been cleared of its overruns. It may take up to 20 seconds to clear the overruns. This command can be sent in either Science or Maintenance/Safe modes.

### 3.1.2.1.3 Timers and Checksum Utilities

The Timers utility exists to provide applications with stopwatch like functions to generate time dependent events.

The Checksum utility computes the checksum of whatever buffer is designated by the calling routine. The result of the checksum is an unsigned Exclusive OR (XOR) of all bytes in the designated buffer.

### 3.1.2.1.4 Memory Load Utility

The NISTAR flight software supports memory loading with a memory load utility. There is no telemetry associated with this utility. Therefore the only confirmations of successful memory loads are accepted commands.

The Integrated Test and Operations System (ITOS) image load tool is used to uplink all NISTAR memory loads. Refer to the ITOS User's Guide for more information on the image load tool. The process of loading anything to NISTAR memory is the same and described in detail in this section.

First a raw image load file must be in the /home/DSCOVER/loads directory or the /home/DSCOVER/loads/nistar directory on the ITOS command workstation. This raw image load file must look similar to the example in Figure 3-8.





```

File Upload of memory
NISTAR,5-Commands,01-127:19:45:17,001,bin2itosVersion1.0,003E,NOSWAP
/NIMEMWRTINIT ADDRESS=H'0059B4B0', NUMBYTES=123
/NIMEMWRITE
/NIMEMCHKSUM CHKSUM=H'70'
;
X 00 00 53 6D 61 6C 6C 20 74 65 73 74 20 66 69 6C 65 2E 0A 4D 65 64 69 75;
X 00 01 20 77 68 69 63 68 20 69 73 20 69 74 3F 0A 0A 0A 0A 0A 0A 0A 0A;
X 00 02 67 20 75 70 21 0A 0A 00 00 00 00 00 00 00 00 00 00 00 00 00;

```

**Figure 3-8. NISTAR Raw Image Load File**

ITOS reads the first line in the raw image load file as a comment line. This line is copied to the formatted image load file but otherwise ignored. This line may contain anything and for NISTAR will contain the file upload type (memory, file or table.)

The second line of the raw image load file consists of several comma-separated fields listed and explained below.

- Mission name – this field is ignored by ITOS, but for NISTAR loads will contain the word NISTAR so that operations personnel may easily identify the load.
- Image ID – this field is ignored by ITOS, but for NISTAR will contain the total number of commands in the load including the INIT, WRITE, and CHKSUM commands. This number will be read via script call by the ITOS NISTAR memory uplink System Test and Operations Language (STOL) procedure so that the load command number can be verified against what is received by the spacecraft.
- Date – this field contains the Greenwich Mean Time (GMT) date and time that the file was built. This field is copied to the formatted image load file, but is otherwise ignored.
- Version – this field contains the version number of the load. This field is ignored by ITOS.
- Source – this field contains information about where the file was built. This field is ignored by ITOS.
- Packet Size – ITOS formats the raw image load file into packets. This is the maximum number of data bytes in each packet. For NISTAR that number will always be 0x3E, which is the maximum length of a NISTAR command.
- Swap – This indicates whether or not the LOAD directive should swap bytes when generating the formatted image load file. For NISTAR loads this field will always indicate NOSWAP.

The third line of the raw image load file is the select command. This command will be uplinked before the load data. This command will prepare the NISTAR flight software for the memory data that is about to be uplinked. The allowable commands for this line are detailed below.



- NIFILWRTINIT – this command prepares the NISTAR flight software for a file uplink to memory. This command requires two other fields which are BYTES = total number of bytes to write to memory, and FILE = filename (standard ASCII string).
- NIMEMWRTINIT – this command prepares the NISTAR flight software for an uplink of bytes to specified locations in memory. The required command fields are ADDRESS = start address where data is to be written, and NUMBYTES = total number of bytes to write to memory.
- NITBLWRTINIT – this command prepares the NISTAR flight software for an uplink of a table to memory. One of the required fields for this command is ID = table identification number of the table that is being uplinked. The available IDs and their related table name are listed here.

- 17, TBL\_FW\_MOTOR
- 18, TBL\_FW\_OTHERS
- 24, TBL\_FW\_SWITCH\_CNT
- 11, TBL\_HS\_OBJECT
- 12, TBL\_HS\_PARAM
- 10, TBL\_HS\_TLM
- 0, TBL\_MEMWRITE\_OBJECT
- 14, TBL\_PD\_OBJECT
- 15, TBL\_PD\_PARAM
- 13, TBL\_PD\_TLM
- 2, TBL\_RC1\_OBJECT
- 3, TBL\_RC1\_PARAM
- 1, TBL\_RC1\_TLM
- 5, TBL\_RC2\_OBJECT
- 6, TBL\_RC2\_PARAM
- 4, TBL\_RC2\_TLM
- 8, TBL\_RC3\_OBJECT
- 9, TBL\_RC3\_PARAM
- 7, TBL\_RC3\_TLM
- 22, TBL\_SHUTTER\_AREA
- 16, TBL\_SHUTTER\_OBJECT
- 23, TBL\_SHUTTER\_SWITCH\_CNT
- 20, TBL\_SIGGEN\_OBJECT
- 21, TBL\_SIGGEN\_PARAM
- 19, TBL\_TSC
- 25, TBL\_VERSION\_NUMBER

The other two required fields for this command are OFFSET = the number of bytes from the start of the table that the data upload will begin (this allows partial tables to be uploaded), and BYTES = the total number of bytes to be written to memory.

The fourth line of the raw image load file is the load command. This command will prompt ITOS to uplink the load data. For all NISTAR memory loads the command is NIMEMWRITE.



The fifth line of the raw image load file for NISTAR is the checksum command. This command will be uplinked by ITOS after the load data. For NISTAR this command is NIMEMCHKSUM and the required field is CHKSUM, which is the checksum for the data that is to be written.

Any part of a line in the raw image load file after a ";" is considered a comment and is ignored by ITOS. The remaining lines in the raw image load file preceded by an "X" are the memory data that is to be uplinked.

The next step in the loading process is making sure that the instrument flight software is in Maintenance/Safe mode. The instrument will not accept memory commands in any other mode than Maintenance/Safe mode (i.e. memory loading cannot be accomplished in Science mode.)

To begin uplinking the load data via the ITOS "/Load" directive should be issued from the ITOS command workstation. This directive requires the complete file name with extension (including the path if the load is not in the CMed, Operational Load Directory) of the raw image load file as a field. After this directive is issued, ITOS will format the raw image load file into a formatted load file. ITOS then reads this file and sends the commands in the file to the spacecraft.

The data that is uplinked to NISTAR memory is first written to a holding buffer. After the checksum command is sent to the instrument, the flight software does a comparison on the uplinked checksum and the checksum that the flight software does itself on the data that was uplinked. If the two checksums do not match the command to write the data to memory is rejected. The command to write the data to memory is NICOMMIT and must be sent from the ground after the ITOS image load process is complete. This is the last step in the memory loading process. This command has one data field, MEM, which can have values of:

- BEEPROM – data will be written to Boot EEPROM to the destination address specified in the memory write initialize command.
- EEPROM – data will be written to the modifiable EEPROM to the destination address specified in the memory write initialize command.
- RAM – data will be written to RAM to the destination address specified in the memory write initialize command.

The NICOMMIT command will also be rejected if any of the previous memory related commands failed. If this happens, the whole process must be restarted to reinitialize the flight software to accept memory data.

The STOL NISTAR Memory Load procedure should be used to uplink all memory loads to the instrument. This procedure prompts the user for the load name, reads the load to determine the number of load commands, executes the /LOAD directive, prompts the user to commit the load and calls the nicommit STOL procedure to do so.

### 3.1.2.1.5 Memory Dump Utility



NISTAR flight software also supports memory inspection through a memory dump utility. There are two basic ways of dumping memory data. The most simple, but least versatile method is through regularly downlinked telemetry. The second more complex and more useful method involves commanding a special APID for memory data downlink to be collected in a file on the ground. Data dumping can be performed in either Science or Maintenance/Safe modes.

#### 3.1.2.1.5.1 Memory Dumping Through Regular Telemetry

In this scenario, there are two commands that can be sent to start the downlink of memory data.

- NIMEMDUMP – this command will start the downlink of data from memory by specified address (ADDRESS is a field of the command.) Both EEPROM and RAM may be inspected with this command.
- NITBLDUMP – this command will dump all or part of a memory table. Required parameters include ID = table identification number, and OFFSET = number of bytes from the start of the table to begin dumping from. To dump the entire table this field is zero. Both EEPROM and RAM may be inspected with this command.

After the command is sent, the instrument validates the address. If the address is invalid the command is rejected. If the address is valid the requested data is downlinked in the following telemetry mnemonics.

- NIMDADD – this echoes the start address of the dumped data.
- NIMDW1 – 29 – these are words 1 through 29 of the dumped data.
- NIMDCHKSUM – this is a checksum of the dumped data.

This telemetry can be viewed on ITOS page NIMEMDUMP.

The ITOS STOL procedure nimemdumpp can be used to dump memory by address through regular telemetry. This procedure prompts the user to input the start address of the dump and then sends the appropriate command.

The ITOS STOL procedure nitbldumpp can be used to dump memory by table through regular telemetry. This procedure prompts the user to input the table ID number and any desired offset.

#### 3.1.2.1.5.2 Memory Dumping Through APID 90

Another scenario exists for memory dumping which utilizes a special NISTAR APID to downlink the data to be captured on the ground via an ITOS sequential print. This sequential print can then be translated into a format that can be compared to the uplink file or ground image file. The process for utilizing this scenario is described here.



First the DSCOVER Computational Hub (CompHub) must be commanded to begin collecting data from the NISTAR remote terminal (RT) subaddresses 20 through 24. This memory dump data is packaged into APID 90 and sent to the ground by the CompHub. The CompHub does not normally collect this data from NISTAR so the schedule table must be commanded to begin collecting the data. This is done with command /SHSLOTENA SLOTNUM=75, ENTRYNUM=0. This command tells the CompHub to enable slot number 75, entry number 0 in the schedule table. Enabling this slot will begin the CompHub collection and downlink of NISTAR APID 90. To read more on the CompHub schedule table refer to the DSCOVER C&DH Software Documentation at <http://sunland.gsfc.nasa.gov/~cdhsw/DSCOVER/cdhswtop.htm>.

APID 90 contains telemetry mnemonics NIMEMDUMP00 – NIMEMDUMP79. The content of these mnemonics is static if APID 90 is not being downlinked by the CompHub. When the CompHub is downlinking APID 90 but the NISTAR software is not dumping memory data the content of these mnemonics is 'bebebebe'. This is referred to as the null pattern. This data can be seen on the ITOS page NIMEMDUMPDATA.

After APID 90 has begun to downlink, the ITOS sequential print nimemdumpp should be started on the ITOS system. This sequential print writes the value of every update of the NIMEMDUMP00 – 79 mnemonics in telemetry into a text file.

After the sequential print has been opened the NISTAR flight software can be commanded to start outputting the desired memory dump data through subaddresses 20 – 24. There are a few commands to do so which are explained here.

- NIFILEDUMP – this command begins or terminates the inspection of a memory by file or allows the user to perform a directory listing on a specified disk. This command requires two fields:
  - FILENAME – this field is the name of the file to be dumped.
  - DUMP\_LOC\_TYPE – this field allows the user to specify which directory to list, what portion of memory to dump a file from. The values are listed below.
    - BOOT – selects the file from the BOOT EEPROM disk
    - NORM – selects the file from the Modifiable EEPROM disk
    - TEMP – selects the file from the RAM disk
    - DIR\_BOOT – selects a directory listing of the targ/boot disk
    - DIR\_NORM – selects a directory listing of the targ/norm disk
    - DIR\_TEMP – selects a directory listing of the targ/temp disk
- NICURTBLDUMP – this command dumps a table from RAM. The only required field is TABLEID, which is the identification number of the table to be dumped. A list of these IDs is in Section 3.1.2.1.4.
- NIMEMDUMP90 – this command dumps memory from the specified address. The required fields are:
  - TYPE – DEFAULT will dump memory
  - ADDRESS – start address of memory to dump
  - BYTES – number of bytes to dump from memory



After the dump begins with one of the commands from above, the user will know the dump is complete by observing the null pattern again in all the memory dump telemetry mnemonics. When the null pattern is received again the sequential print, nimemdump, that was opened to collect the dump data can be closed.

At the conclusion of the dump, the CompHub must be commanded to stop collecting data from NISTAR for APID 90. The command to do this is /SHSLOTDIS SLOTNUM=75, ENTRYNUM=0. This disables the slot in the schedule table responsible for causing the CompHub to collect NISTAR data for APID 90.

Several ITOS STOL procedures exist to perform memory dumping using this method. The nicurtbldump procedure will dump a table from RAM, nidirdump will perform the desired directory listing, the nifiledump procedure will dump the desired file, and the nimemdump\_90 procedure will dump memory from the specified address for the specified number of bytes. All procedures will command the schedule table, open the sequential print, send the command to start dumping the memory, determine when the dump is complete, close the sequential print, and command the schedule table again. The procedure takes care of commanding the schedule table and closing the sequential print.

A script exists on the ITOS system called nfdrecover that will convert the sequential print output file into a form that can be compared to an uplink file or a file that exists as part of the NISTAR software developers system. To run the script in the /home/DSCOVER/DSCOVER\_tc/max directory type nfdrecover followed by the sequential print output file name. The sequential print output file must also be located in this directory. The output of this script will be located in the directory by the name of the disk that the table data was dumped from (/home/DSCOVER/DSCOVER\_tc/max/targ/boot or /home/DSCOVER/DSCOVER\_tc/max/targ/norm or /home/DSCOVER/DSCOVER\_tc/max/targ/temp) and will have a recognizable name. The output will be located in the /home/DSCOVER/DSCOVER\_tc/max/memdump directory if the memory dump was by address.

#### **3.1.2.1.6 MIL-STD-1553 Interface**

A MIL-STD-1553 (1553) interface exists as part of the I/O Card. This hardware interface is driven by the operating system I/O drivers and provides the interface for communication of telemetry and commands between the DSCOVER CompHub and the NISTAR ICE. NISTAR is RT 9 on the DSCOVER 1553 bus.

A 1553 BIT monitors the health of the 1553 interface and is reported in telemetry mnemonic NI1553BIT. This mnemonic can have values of either "PASS" or "FAIL". If the channel is down or the bits transferred get corrupted the BIT will be failed.

#### **3.1.2.1.7 Quad High-Speed Serial Interface**

A QHSS interface exists as part of the I/O Card. This hardware interface is driven by the operating system I/O drivers and provides the interface for communication of telemetry and commands to the shutters, filter wheel, heater drivers, temperature sensors and photodiode.





There are three separate FPGAs, which utilize separate QHSS ports. These FPGAs are referred to as the “Science”, “Housekeeping”, and “Motor” FPGA. The instrument actually has four FPGAs, but only three are used. A BIT is performed on each QHSS connection to determine the health of data flow over the QHSS port to its FPGA. The BIT will fail when the data or commands are not synchronized on the QHSS. Once communication has been reestablished for more the 50 packets the status is passed. The QHSS BIT status is reported in the telemetry mnemonics listed in Table 3-5.

**Table 3-5. QHSS BIT Telemetry**

| <b>Mnemonic</b>                     | <b>Description</b>                                                               |
|-------------------------------------|----------------------------------------------------------------------------------|
| NIQHSSHKBIT – QHSS Housekeeping BIT | Status of the QHSS Housekeeping FPGA BIT. Possible values are “PASS” and “FAIL”. |
| NIQHSSMTRBIT – QHSS Motor BIT       | Status of the QHSS Motor FPGA BIT. Possible values are “PASS” and “FAIL”.        |
| NIQHSSSCIBIT – QHSS Science BIT     | Status of the QHSS Science FPGA BIT. Possible values are “PASS” and “FAIL”.      |

Other data that is transferred over the QHSS from the FPGAs is explained in Table 3-6.

**Table 3-6. QHSS Telemetry**

| <b>Mnemonic</b>                                       | <b>Description</b>                                                                                                                     |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| NISCRC1PTCBSY – Subsystem Control RC1 PTC Heater Busy | If this bit is high, the data is invalid for telemetry mnemonic NIRC1BNOMRW because the Analog/Digital Converter (ADC) is calibrating. |
| NISCRC2PTCBSY - Subsystem Control RC2 PTC Busy        | If this bit is high, the data is invalid for telemetry mnemonic NIRC2BNOMRW because the ADC is calibrating.                            |
| NISCRC3PTCBSY - Subsystem Control RC3 PTC Busy        | If this bit is high, the data is invalid for telemetry mnemonic NIRC3BNOMRW because the ADC is calibrating.                            |
| NISCHSPTCBSY - Subsystem Control HS PTC Busy          | If this bit is high, the data is invalid for telemetry mnemonic NIHSBNOMRW because the ADC is calibrating.                             |
| NISCRC1HTRBSY - Subsystem Control RC1 Heater Busy     | If this bit is high, the data is invalid for telemetry mnemonic NIRC1HADCRW because the ADC is calibrating.                            |
| NISCRC2HTRBSY - Subsystem Control RC2 Heater Busy     | If this bit is high, the data is invalid for telemetry mnemonic NIRC2HADCRW because the ADC is calibrating.                            |
| NISCRC3HTRBSY- Subsystem Control RC3 Heater Busy      | If this bit is high, the data is invalid for telemetry mnemonic NIRC3HADCRW because the ADC is calibrating.                            |
| NISCPDBSY - Subsystem Control PD Busy                 | If this bit is high, the data is invalid for telemetry mnemonic NIPDADCRW because the ADC is calibrating.                              |
| NISCEXTWDT - Subsystem Control External               | If this bit is high, all data from the board is in                                                                                     |



| Mnemonic                                                                         | Description                                               |
|----------------------------------------------------------------------------------|-----------------------------------------------------------|
| Watch Dog Timer (from Science Analog Board)                                      | error.                                                    |
| NISCLOCWDT - Subsystem Control Local Watch Dog Timer (from Science Analog Board) | If this bit is high, all data from the board is in error. |

### 3.1.2.1.8 Built-In-Test

The Built-In-Test (BIT) function exists as part of the operating system to monitor and report the health of the other utilities of the flight software. Each type of test performed by the BIT function will be discussed as part of the other utilities' sections.

### 3.1.2.1.9 Subsystem Control

#### 3.1.2.1.9.1 DSCOVN Spacecraft Task

The TSC task handles the communication between the NISTAR ICE and the DSCOVN CompHub. It reads and processes new commands from the 1553 bus, gathers telemetry data and formats it into 1553 messages and sends the messages to the 1553 bus. The NISTAR RT on subaddress 1 receives commands. Commands are processed at 8Hz.

The SiPD data is measured at 10Hz and stored and downlinked at 1 Hz. All other science data is measured, stored and downlinked at 1Hz. Housekeeping data is measured, stored, and downlinked at 0.1 Hz. The data volume from NISTAR is 2400 bits per second (bps). NISTAR telemetry is continuously downlinked in Virtual Channel (VC) 0 and stored on the spacecraft Solid State Recorder (SSR) on the SCI partition. A telemetry counter is provided to ensure data transmission integrity.

The TSC has a five-second interface timer, which is changeable through a memory upload. If this timer expires, meaning there has been no communication from the DSCOVN CompHub in the last five seconds, the TSC BIT bit is set to failed and the TSC commands an automatic entry to maintenance/safe mode. This BIT is telemetered through mnemonic NITSCBIT and has a value of either "PASS" or "FAIL".

The TSC task also provides the number of accepted and rejected commands in telemetry. These are mnemonics NICMDCNT and NIERRCNT respectively.





One TSC related command is explained below:

NICMDRESET – This command will reset the NISTAR command counters (telemetry mnemonics NICMDCNT and NIERRCNT) to 1 and 0 respectively. This command can be sent in either Science or Maintenance/Safe modes.

### 3.1.2.1.9.2 Heaters Task

The Heaters task handles much of the science related functions such as heater temperature control mode commanding, tuning parameter commanding, sine wave generation, and using data from the FPGA.

A BIT is performed on this task which fails if a division by zero is attempted. The data from the Heaters task will not be valid until the BIT passes. The status of the BIT is telemetered in the mnemonics listed in Table 3-7.

**Table 3-7. Heaters Task BIT Telemetry**

| <b>Mnemonics</b>                    | <b>Description</b>                                                                                          |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------|
| NIHSHTRBIT – HS Heater BIT Status   | Reports the status of the BIT performed on the Heat Sink Heater. Possible values are “PASS” and “FAIL”.     |
| NIRC1HTRBIT – RC1 Heater BIT Status | Reports the status of the BIT performed on Receiver Cavity 1 Heater. Possible values are “PASS” and “FAIL”. |
| NIRC2HTRBIT – RC2 Heater BIT Status | Reports the status of the BIT performed on Receiver Cavity 2 Heater. Possible values are “PASS” and “FAIL”. |
| NIRC3HTRBIT – RC3 Heater BIT Status | Reports the status of the BIT performed on Receiver Cavity 3 Heater. Possible values are “PASS” and “FAIL”. |

Other telemetry related to this task is presented in Table 3-8.



**Table 3-8. Heaters Task Telemetry**

| <b>Mnemonics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Description</b>                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| NIHSPTCRSP – Heat Sink PTC Resistance Setpoint<br>NIRC1PTCRSP – RC 1 PTC Resistance Setpoint<br>NIRC2PTCRSP – RC 1 PTC Resistance Setpoint<br>NIRC3PTCRSP – RC 1 PTC Resistance Setpoint                                                                                                                                                                                                                                                                                                                                                                                                                                | The commanded value for the PTC resistance setpoint temperature when running in closed loop temperature control for the appropriate RC or HS. |
| NIRC1FOPRECHRG A - RC1 fixed open precharge value for filter A<br>NIRC2FOPRECHRG A - RC2 fixed open precharge value for filter A<br>NIRC3FOPRECHRG A - RC3 fixed open precharge value for filter A<br>NIRC1FOPRECHRG B - RC1 fixed open precharge value for filter B<br>NIRC2FOPRECHRG B - RC2 fixed open precharge value for filter B<br>NIRC3FOPRECHRG B - RC3 fixed open precharge value for filter B<br>NIRC1FOPRECHRG C - RC1 fixed open precharge value for filter C<br>NIRC2FOPRECHRG C - RC2 fixed open precharge value for filter C<br>NIRC3FOPRECHRG C - RC3 fixed open precharge value for filter C          | The commanded value of the fixed open precharge value for the drop floor algorithm for the appropriate RC and filter type.                    |
| NIRC1FCPRECHRG A - RC1 fixed close precharge value for filter A<br>NIRC2FCPRECHRG A - RC2 fixed close precharge value for filter A<br>NIRC3FCPRECHRG A - RC3 fixed close precharge value for filter A<br>NIRC1FCPRECHRG B - RC1 fixed close precharge value for filter B<br>NIRC2FCPRECHRG B - RC2 fixed close precharge value for filter B<br>NIRC3FCPRECHRG B - RC3 fixed close precharge value for filter B<br>NIRC1FCPRECHRG C - RC1 fixed close precharge value for filter C<br>NIRC2FCPRECHRG C - RC2 fixed close precharge value for filter C<br>NIRC3FCPRECHRG C - RC3 fixed close precharge value for filter C | The commanded value of the fixed close precharge value for the drop floor algorithm for the appropriate RC and filter type.                   |



| Mnemonics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIRC1AOPRECHRG0 - nominally RC1 auto open precharge value for filter A<br>NIRC2AOPRECHRG0 - nominally RC2 auto open precharge value for filter A<br>NIRC3AOPRECHRG0 - nominally RC3 auto open precharge value for filter A<br>NIRC1AOPRECHRG1 - nominally RC1 auto open precharge value for filter B<br>NIRC2AOPRECHRG1 - nominally RC2 auto open precharge value for filter B<br>NIRC3AOPRECHRG1 - nominally RC3 auto open precharge value for filter B<br>NISPARE1 - nominally RC1 auto open precharge value for filter C<br>NISPARE5 - nominally RC2 auto open precharge value for filter C<br>NISPARE3 - nominally RC3 auto open precharge value for filter C          | The commanded value of the auto open precharge value for the drop floor algorithm for the appropriate RC and filter type.<br>Note: Observed behavior is not what is expected by flight software. Expected behavior by flight software is given by nominal descriptions to the left. However, the observed behavior is that these mnemonics are used independently of the filter type (i.e. all mnemonics are used for each type) and the NISPARE values are correlated with the sum of the values of the 0, 1 mnemonics that precede it.  |
| NIRC1ACPRECHRG0 - nominally RC1 auto close precharge value for filter A<br>NIRC2ACPRECHRG0 - nominally RC2 auto close precharge value for filter A<br>NIRC3ACPRECHRG0 - nominally RC3 auto close precharge value for filter A<br>NIRC1ACPRECHRG1 - nominally RC1 auto close precharge value for filter B<br>NIRC2ACPRECHRG1 - nominally RC2 auto close precharge value for filter B<br>NIRC3ACPRECHRG1 - nominally RC3 auto close precharge value for filter B<br>NISPARE4 - nominally RC1 auto close precharge value for filter C<br>NISPARE2 - nominally RC2 auto close precharge value for filter C<br>NISPARE6 - nominally RC3 auto close precharge value for filter C | The commanded value of the auto close precharge value for the drop floor algorithm for the appropriate RC and filter type.<br>Note: Observed behavior is not what is expected by flight software. Expected behavior by flight software is given by nominal descriptions to the left. However, the observed behavior is that these mnemonics are used independently of the filter type (i.e. all mnemonics are used for each type) and the NISPARE values are correlated with the sum of the values of the 0, 1 mnemonics that precede it. |
| NIHSPRECHRGMOD – HS commanded precharge mode<br>NIRC1PRECHRGMOD – RC1 commanded precharge mode<br>NIRC2PRECHRGMOD – RC2 commanded precharge mode<br>NIRC3PRECHRGMOD – RC3 commanded precharge mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | The commanded value for the appropriate HS or RC precharge mode.<br>Possible values are “FIXED”, “AUTO”, or “OFF”.<br>Note that for HS “AUTO” and “OFF” modes are equivalent                                                                                                                                                                                                                                                                                                                                                              |
| NIHSPID2P – HS PID2 P tuning parameter<br>NIRC1PID2P – RC1 PID2 P tuning parameter<br>NIRC2PID2P – RC2 PID2 P tuning parameter<br>NIRC3PID2P – RC3 PID2 P tuning parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | The commanded value for the PID (Proportional Integral Derivative) 2 P tuning parameter for the appropriate RC or HS                                                                                                                                                                                                                                                                                                                                                                                                                      |



| Mnemonics                                                                                                                                                                                                      | Description                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| NIHSPID2I – HS PID2 I tuning parameter<br>NIRC1PID2I – RC1 PID2 I tuning parameter<br>NIRC2PID2I – RC2 PID2 I tuning parameter<br>NIRC3PID2I – RC3 PID2 I tuning parameter                                     | The commanded value for the PID2 I tuning parameter for the appropriate RC or HS                                                     |
| NIHSPID2D – HS PID2 D tuning parameter<br>NIRC1PID2D – RC1 PID2 D tuning parameter<br>NIRC2PID2D – RC2 PID2 D tuning parameter<br>NIRC3PID2D – RC3 PID2 D tuning parameter                                     | The commanded value for the PID2 D tuning parameter for the appropriate RC or HS                                                     |
| NIHSPID2K – HS PID2 K tuning parameter<br>NIRC1PID2K – RC1 PID2 K tuning parameter<br>NIRC2PID2K – RC2 PID2 K tuning parameter<br>NIRC3PID2K – RC3 PID2 K tuning parameter                                     | The commanded value for the PID2 K Loop tuning parameter for the appropriate RC or HS                                                |
| NIHSSINWVFRQ – HS Sine Wave Frequency<br>NIRC1SINWVFRQ – RC1 Sine Wave Frequency<br>NIRC2SINWVFRQ – RC2 Sine Wave Frequency<br>NIRC3SINWVFRQ – RC3 Sine Wave Frequency                                         | The commanded value of the sine wave frequency for the appropriate RC or HS.                                                         |
| NIHSTEMPCTRL – HS temperature control loop mode<br>NIRC1TEMPCTRL – RC1 temperature control loop mode<br>NIRC2TEMPCTRL – RC2 temperature control loop mode<br>NIRC3TEMPCTRL – RC3 temperature control loop mode | The commanded setting for the temperature control loop for the appropriate RC or HS (either “OPEN LOOP” or “CLOSED LOOP”)            |
| NIRC1DIFFMODE – RC1 differential control mode<br>NIRC2DIFFMODE – RC1 differential control mode<br>NIRC3DIFFMODE – RC1 differential control mode                                                                | The commanded setting for the control mode for the appropriate RC. The possible values are “ABS”, “W/RC1”, “W/RC2”, “W/RC3”, “W/HS”. |
| NIHSADCCALST – HS ADC Calibration Status<br>NIRC1ADCCALST – RC1 ADC Calibration Status<br>NIRC2ADCCALST – RC2 ADC Calibration Status<br>NIRC3ADCCALST – RC3 ADC Calibration Status                             | The current status of the HS or RC ADC calibration. Possible values are “NOT CALIBRATING” and “CALIBRATING”.                         |



| Mnemonics                                                                                                                                                                                          | Description                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| NIHSCURRCALTIC – HS current calibration tick<br>NIRC1CURRCALTIC – RC1 current calibration tick<br>NIRC2CURRCALTIC – RC1 current calibration tick<br>NIRC3CURRCALTIC – RC1 current calibration tick | The current calibration tick for the appropriate HS or RC will equal zero when calibration is complete. During calibration it will count up. |
| NIPDHSPRECHRG – PD HS Precharge value<br>NIRC1HSPRECHRG – RC1 HS Precharge value<br>NIRC2HSPRECHRG – RC1 HS Precharge value<br>NIRC3HSPRECHRG – RC1 HS Precharge value                             | The commanded value of the appropriate PD or RC HS precharge value.<br>Note: These values are ignored unless HS is in “FIXED” precharge mode |

Other Heaters task related commands are presented below.

NIPTCRSP – Sets the desired PTC resistance temperature setpoint when running in closed loop temperature control for the selected RC or HS. This command can only be sent in Science mode.

NIFOPRECHRG – Sets the fixed open precharge value for the drop floor algorithm for the specified RC and filter type. This command can only be sent in Science mode.

NIFCPRECHRG – Sets the fixed close precharge value for the drop floor algorithm for the specified RC and filter type. This command can only be sent in Science mode.

NIAOPRECHRG – Sets the auto open precharge value for the drop floor algorithm for the specified RC and filter type. This command can only be sent in Science mode. See note above: observed behavior differs from behavior expected by the flight software.

NIACPRECHRG – Sets the auto close precharge value for the drop floor algorithm for the specified RC and filter type. This command can only be sent in Science mode. See note above: observed behavior differs from behavior expected by the flight software.

NIPRECHRGMOD – Sets the software to use the fixed precharge values, the automated precharge mode, or disable the floor/guess for the selected HS or RC. This command can only be sent in Science mode.

NIPID2P – Sets the tuning parameter PID2 P for the selected RC or HS. This command can only be sent in Science mode.

NIPID2I – Sets the tuning parameter PID2 I for the selected RC or HS. This command can only be sent in Science mode.



NIPID2D – Sets the tuning parameter PID2 D for the selected RC or HS. This command can only be sent in Science mode.

NIPID2K – Sets the tuning parameter PID2 K Loop for the selected RC or HS. This command can only be sent in Science mode.

NISINWVFRQ – Sets the sine wave frequency value for the selected RC or HS. The frequency value must be in the range of 35 – 155. This command can only be sent in Science mode.

NITEMPCTRL – Opens or closes the temperature control loop for the selected RC or HS. This command can only be sent in Science mode.

NIDIFFMODE – Selects the control loop mode for the selected RC. The commanded values can be absolute, differential with respect to RC1, differential with respect to RC2 and differential with respect to RC3. This command can only be sent in Science mode.

NISTARTCAL – Starts the selected calibration procedure(s) (All, ADC, PTC, HTR) for the selected RC or HS. If selected, the “All” calibrations and “ADC” calibrations will be executed for all four heaters (RC1, RC2, RC3, and HS) regardless of RC or HS selection.

NIHSPRECHRG – Sets the HS precharge value for the selected RC or PD. Values only used when HS is in “FIXED” precharge mode.

### 3.1.2.1.9.3 Shutters Task

The Shutters task controls the movement of the shutters. It acts upon input it gets from the FPGA task and from ground commanding.

The Shutters task has a BIT that is performed on it which will be failed at software initialization, if the calibration of a shutter fails, and if a limit switch is hit. It will be passed otherwise. The status of the BIT is telemetered and displayed through the mnemonics listed in Table 3-9.

**Table 3-9. Shutters Task BIT Telemetry**

| <b>Mnemonics</b>               | <b>Description</b>                                                                                           |
|--------------------------------|--------------------------------------------------------------------------------------------------------------|
| NIPDSHTRBIT – PD Shutter BIT   | Reports the status of the BIT performed on the Photodiode Shutter. Possible values are “PASS” and “FAIL”.    |
| NIRC1SHTRBIT – RC1 Shutter BIT | Reports the status of the BIT performed on Receiver Cavity 1 Shutter. Possible values are “PASS” and “FAIL”. |
| NIRC2SHTRBIT – RC2 Shutter BIT | Reports the status of the BIT performed on Receiver Cavity 2 Shutter. Possible values are “PASS” and “FAIL”. |
| NIRC3SHTRBIT – RC3 Shutter BUT | Reports the status of the BIT performed on Receiver Cavity 3 Shutter. Possible values are “PASS” and “FAIL”. |



The Shutters task also calculates the shutter area. This area is really an indication of how much of the aperture is open or exposed to radiation based on the shutter step position and is reported as a percentage. The aperture area function is presented in Appendix C. The shutter area is telemetered in the mnemonics in Table 3-10.

**Table 3-10. Shutter Task Telemetry**

| <b>Mnemonics</b>             | <b>Description</b>                               |
|------------------------------|--------------------------------------------------|
| NIPDAREA – PD Shutter Area   | Percentage of PD aperture exposed to radiation.  |
| NIRC1AREA – RC1 Shutter Area | Percentage of RC1 aperture exposed to radiation. |
| NIRC2AREA – RC2 Shutter Area | Percentage of RC2 aperture exposed to radiation. |
| NIRC3AREA – RC3 Shutter Area | Percentage of RC3 aperture exposed to radiation. |

Other shutter related telemetry and commands are presented in Section 3.1.1.2.

#### **3.1.2.1.9.4 Filter Wheel Task**

The Filter Wheel task controls the movement of the filter wheel. It acts upon input it gets from the FPGA task and from ground commanding.

The filter wheel task has a BIT that is performed on it which will be failed at software initialization, if the calibration of the filter wheel fails, if a limit switch is hit. It will be passed otherwise. The status of the BIT is telemetered in mnemonic NIFWBIT and has a value of “PASS” or “FAIL”.

Other filter wheel related telemetry and commands are presented in Section 3.1.1.1.

#### **3.1.2.1.9.5 Silicon Photodiode Task**

The PD task samples PD data from the SC FPGA task at 10Hz and places it in the 1Hz telemetry to achieve a 10Hz data rate for the PD current. The mnemonics associated with this current are listed in the first two blocks of Table 3-11. The combination and arithmetic of the data in these first two blocks compute the current. Telemetry associated with the PD task is listed in Table 3-11.





**Table 3-11. Silicon Photodiode Task Telemetry**

| <b>Mnemonic</b>                                                                                                                                                                                                               | <b>Description</b>                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| NIPDADCAVG10HZ1 - PD ADC Average<br>10Hz Sample 1<br>NIPDADCAVG10HZ2<br>NIPDADCAVG10HZ3<br>NIPDADCAVG10HZ4<br>NIPDADCAVG10HZ5<br>NIPDADCAVG10HZ6<br>NIPDADCAVG10HZ7<br>NIPDADCAVG10HZ8<br>NIPDADCAVG10HZ9<br>NIPDADCAVG10HZ10 | Photodiode ADC Average sampled at 10Hz.<br>Mnemonics are named by sample number 1 – 10. |
| NIPDDACAVG10HZ1 – PD DAC Average<br>10Hz Sample 1<br>NIPDDACAVG10HZ2<br>NIPDDACAVG10HZ3<br>NIPDDACAVG10HZ4<br>NIPDDACAVG10HZ5<br>NIPDDACAVG10HZ6<br>NIPDDACAVG10HZ7<br>NIPDDACAVG10HZ8<br>NIPDDACAVG10HZ9<br>NIPDDACAVG10HZ10 | Photodiode DAC Average sampled at 10Hz.<br>Mnemonics are named by sample number 1 – 10. |
| NIPDPID2P – PD PID2 P tuning parameter                                                                                                                                                                                        | The commanded value for the PID2 P tuning parameter for the PD.                         |
| NIPDPID2I – PD PID2 I tuning parameter                                                                                                                                                                                        | The commanded value for the PID2 I tuning parameter for the PD.                         |
| NIPDPID2D – PD PID2 D tuning parameter                                                                                                                                                                                        | The commanded value for the PID2 D tuning parameter for the PD.                         |
| NIPDPID2K – PD PID2 K tuning parameter                                                                                                                                                                                        | The commanded value for the PID2 K Loop tuning parameter PD.                            |

A BIT is performed on this task which fails if a division by zero is attempted. The data from the SiPD task will not be valid until the BIT passes. The status of the BIT is telemetered in mnemonics NIPDBIT and has possible values of “PASS” and “FAIL”.

Other PD task related commands are presented below.

NIPID2P – Sets the tuning parameter PID2 P for the PD. This command can only be sent in Science mode.

NIPID2I – Sets the tuning parameter PID2 I for the PD. This command can only be sent in Science mode.

NIPID2D – Sets the tuning parameter PID2 D for the PD. This command can only be sent in Science mode.





NIPID2K – Sets the tuning parameter PID2 K Loop for the PD. This command can only be sent in Science mode.

### 3.1.2.1.9.6 FPGA Task

The FPGA task is responsible for all communications to and from the FPGAs.

The FPGA task handles several commands that allow direct commanding to the FPGAs. We do not anticipate ever needing to send these commands while the spacecraft is on orbit, but they were tested as part of NISTAR Integration and Test. These commands are currently commented out of the ITOS command database code, but the command structure will remain as part of the database code in case some anomaly on-orbit requires FPGA commanding. The commands are explained below.

NIMTRCTRRS – Motor counter reset command. This command resets the value of the motor step counter (telemetry mnemonic NIMTRSTPCNTCMD) to zero. The motor counter reset bit (telemetry mnemonics NIFWCMDMTRCTRRS, NIPDCMDMTRCTRRS, NIRC1CMDMTRCTRRS, NIRC2CMDMTRCTRRS, NIRC3CMDMTRCTRRS) will flip from “FALSE” to “TRUE” while the counter is being reset for the appropriate motor. However, it will reset so fast that this bit may never be seen toggling in telemetry. This command is valid in Science mode only.

NIMOTORSTOP – This command issues an immediate stop to the specified motor if it is moving. This command is valid in Science mode only. Command parameters include:

Motor – the motor that should be stopped (RC1-3, SP, or FW.)

Speed – the speed that the motor is moving. Possible values are

“S120HZ”, “S80HZ”, “S60HZ”, “S48HZ”, “S40HZ”, “S34HZ”, “S30HZ”, and “S27HZ”.

Direction – the direction that the motor is moving. Possible values are “FORWARD” and “REVERSE”.

Note: The need for the speed and direction in this command when a motor is being stopped has not been explained. When tested this command succeeded in stopping the filter wheel motor no matter what speed or direction was commanded.

NIMTRCTRL - This command sets up the FPGA for a potential motor movement. This command must be followed by the NIMOTORCTRL command to actually move the motor. This command is valid in Science mode only. Command parameters include:



Motor – the motor that should be moved (RC1-3, SD, or FW.)

Speed – the speed that the motor is to be moved. Possible values are “S120HZ”, “S80HZ”, “S60HZ”, “S48HZ”, “S40HZ”, “S34HZ”, “S30HZ”, and “S27HZ”.

Direction – the direction that the motor is moving. Possible values are “FORWARD” and “REVERSE”.

Stepcount – the number of steps the motor is to be moved. One step count is the same as one step position.

Phase – Possible values are “NONE”, “PHASE A”, “PHASE B”, and “PHASE AB”. The stepper motors NISTAR uses have two windings, A and B. The exact location of the motor shaft is determined by which magnetic pole it is near and which combination of windings are energized or not. When power to a motor is turned off, it may drift to the nearest magnetic pole; NISTAR has three magnetic poles. The system turns the power off to the motor when it is not moving, in order to save power and not have the motors heat-up. Stepper motors must have power at all times in order to hold a given position. In order to know where the motor is, you must re-apply power in the same phase that was last used. The shaft will then return to the last position. This command field tells the motor in what phase to apply power.

Holdoff – power holdoff value. This with the speed translates to the time that the FPGA will wait before powering off the motor after movement has completed. See page 27 of the NISTAR Flight Software Interface Control Document Section 2 – QHSS for allowable hold-off values.

NIRAWSCICTRL – This command allows the user to manipulate the science command data that is generated by the FPGA. Refer to the NISTAR Flight Software Interface Control Document Section 2 – QHSS page 29 QHSS Channel 3 NISTAR Science Command data. The command parameters include:

Command - the value of this field will be echoed back in the telemetry for the first 10 bits of the science command word. These mnemonics are:

NIHSPTCCALEN – Heat Sink PTC Calibration Enabled Status

NIRC1HTRCALEN – RC1 Heater Calibration Enabled Status

NIRC1PTCCALEN – RC1 PTC Calibration Enabled Status

NIRC2HTRCALEN – RC2 Heater Calibration Enabled Status

NIRC2PTCCALEN – RC2 PTC Calibration Enabled Status

NIRC3HTRCALEN – RC3 Heater Calibration Enabled Status

NIRC3PTCCALEN – RC3 PTC Calibration Enabled Status

The possible values for these mnemonics are “TRUE”=1 and “FALSE”=0.

WORD1-14 – the values of the fields for WORD1-14 will be echoed back in the telemetry for the 15 words of data in the Science Command data. For example, the value for WORD1 will be echoed in the telemetry for the RC1 Sine Wave Value, which is mnemonic RC1SINWVVAL (RC1 Sine Wave Value). The rest of the mnemonics associated with this command are:

- NIRC2SINWVVAL - RC2 Sine Wave Value



- NIRC1HDACCMD - RC1 HDAC Command
- NIRC2HDACCMD - RC2 HDAC Command
- NIRC1MDACCMD - RC1 MDAC Command
- NIRC2MDACCMD - RC2 MDAC Command
- NIRC3SINWVVAL - RC3 Sine Wave Value
- NIHSSINWVVAL - HS Sine Wave Value
- NIRC3HDACCMD - RC3 HDAC Command
- NIHSHDACCMD - HS HDAC Command
- NIPDDACCMD - PD DAC Command
- NIRC3MDACCMD - RC3 MDAC Command
- NIHSMACCMD - HS MDAC Command

To issue data to the selected word the NISCIGRNDCTRL command must first be issued to enable ground commanding of that word. Description of that command follows.

**NISCIGRNDCTRL** – This command allows the user to enable and the ground commanding of FPGA science data. Only the words that are enabled by this command will be alterable through the NIRAWSICTRL command. Inputs to the command are:

**MODE** – allows user to “DISABLE” or “ENABLE” the selected WORD#

**WORD#** - the word number refers to the word number of the data from the FGPA. Refer to 1553 Ball ICD page 29 QHSS Channel 3 data.

If the user enables word 1, this will stop the FPGA report of data from the first 16 bits of the QHSS Channel 3 Science Command Data and will allow data sent by the NIRAWSICTRL command to be issued.

If the user enables any word from 2 – 15, this will stop the science data from all words of the QHSS Channel 3 Science Command Data from 2 –15 and the enabled word can be issued by the NIRAWSICTRL command. Disabling the same word number will start the collection of the data again.

The status of the words (“TRUE” or “FALSE”) can be seen in telemetry mnemonics NISCIGRNDCTRL1 – NISCIGRNDCTRL15. They will be “FALSE” in normal operation, meaning data from the FPGA is being collected and downlinked.

**NIRAWHKCTRL** – this command allows the user to order the ADC to perform a self-calibration. Normally the ADC is calibrated on boot-up. The command must be a pulse, which means the user must send the command with the WORD parameter as a 1 followed by the same command with the WORD parameter as a 0 to begin the calibration. Telemetry associated with this command are the mnemonics NIHKADCCAL and NISCSTATMD. NIHKADCCAL indicates the status (“TRUE” or “FALSE”) of the NIRAWHKCTRL command WORD parameter. NISCSTATMD indicates the status (“TRUE” or “FALSE”) of the ADC calibration.

**NIMOTORCTRL** – This command allows the user to command the motors to move. The command parameters include:



**CMDWORD** - the value of this parameter should be built by combining the desired values for the each data bit of data word 3 of the QHSS ICD Motor Control Status data, which includes things like motor speed, direction etc.

**WORD1** – the value of this parameter should be built by combining the desired values for the each data bit of data words 4 of the QHSS ICD Motor Control Status data, which includes things like motor speed direction etc.

**WORD2** - the value of this parameter should be the desired values for data word 5 of the QHSS ICD Motor Control Status data.

### 3.1.2.1.10 Mission Management Application

The Mission Management application's purpose is to provide mode management for the flight software, including defining the modes and controlling manual and automated transitions between modes. All instrument actions are mode based.

NISTAR flight software has two main modes of operation, Science and Maintenance/Safe.

Normal NISTAR operation will be accomplished in Science Mode. Also, while in this mode NISTAR's filter wheel will be in a fixed position and the RCs and HS will be in closed loop temperature control. The RC shutters will cycle (open and close) with a 10-minute period and 50% duty cycle. The SiPD shutter will cycle with a 7-day period, with a 5 minute closed period during that 7 days.

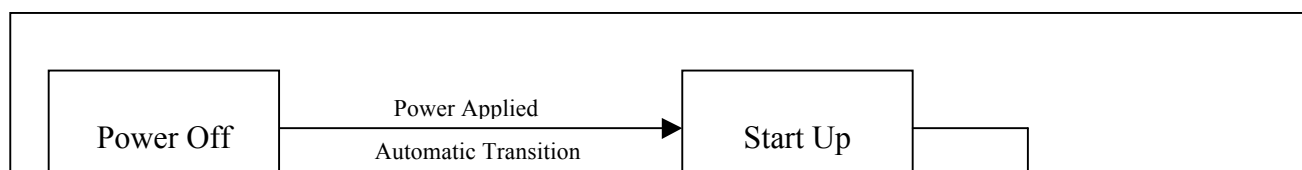
In Maintenance/Safe mode, NISTAR's shutters are automatically closed to prevent contamination. The flight software will enter this mode automatically if NISTAR fails to receive a command from the DSCOVER Command & Data Handling (C&DH) subsystem CompHub 1553 bus within 5 seconds. This automatic entry into Maintenance/Safe mode is called an Autosafe. The temperature control loop will continue to execute in this mode.

All NISTAR flight software operating modes are described in Table 3-12.

**Table 3-12. NISTAR Flight Software Modes**

| Mode # | Modes              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Power Off          | State of the electronics when power is off.                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2      | Start Up           | RAD6000 SUROM start up of processor, electronics, and drivers and NISTAR software initialization.                                                                                                                                                                                                                                                                                                                                                                   |
| 3      | Maintenance / Safe | Allows memory upload and processes to begin execution from RAM. On initial power up, all hardware boards are reset and calibrated. Shutters are closed if open upon entry. All outputs from the instrument are set to a known value in order to safe the instrument from damage by closing the shutters. Generally this mode is entered by a mode command, or when a communication loss from the Triana Comphub occurs for more than 5 seconds, called an Autosafe. |
| 4      | Science            | Normal operations mode.                                                                                                                                                                                                                                                                                                                                                                                                                                             |

Allowable mode transitions and associated constraints are illustrated in Figure 3-7.



### Figure 3-9. NISTAR Flight Software Mode Transitions

An explanation of the telemetry that is associated with the flight software modes and mode transitions is listed in Table 3-13. During power off, start-up and the transition to maintenance/safe mode from start-up, the software is not outputting telemetry to the DSCOVN CompHub. Therefore, there is no telemetry associated with the power off or start-up modes.

**Table 3-13. Mission Management Telemetry**

| <b>Mnemonic</b>                          | <b>Description</b>                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIINSTMODE – NISTAR Flight Software Mode | Reports current NISTAR flight software mode.<br>Possible values are MAINT/SAFE and SCIENCE.<br>After an autosafe occurs, the flight software mode will be maintenance/safe.                                                                                                                                                                                |
| NIMODECMD – Mode Commanding Status       | Reports mode commanding status.<br>Possible values are ARMED and DISARMED.<br>To be able to command a transition between Maintenance/Safe and Science modes, NIMODECMD must be Armed.<br>After an autosafe occurs, mode commanding will be disarmed.<br>After transitioning to maintenance/safe by command or from startup, mode commanding will be armed. |



| Mnemonic                     | Description                                                                    |
|------------------------------|--------------------------------------------------------------------------------|
| NIAUTOSAFE – Autosafe Status | Reports NISTAR autosafe status. Possible values are OCCURRED and NOT OCCURRED. |

There are two commands that are associated with flight software mode transitions. Their description follows.

**NIINSTMODE** - This command will allow the user to change the flight software mode to either Maintenance/Safe or Science. Mode commands must be armed for this command to be accepted. Commanding the flight software to the mode that it is already in has no effect on the flight software except to increment the command counters. (I.e. the software will continue executing from its current state. No tasks are reloaded or restarted.)

**NIMODECMD** – This command allows the user to arm or disarm mode commanding. With mode commanding disarmed, commanded transitions between maintenance safe mode and science mode are not possible.

### 3.1.2.1.11 Configurator

The configurator is the part of the software that configures the remainder of the system. It is where the code resides that takes control from the operating system to start and stop the instrument. The task manager and all of the individual tasks (such as the shutter, heater, etc.) are instantiated by the configurator. Also, the data storage interrupt (DSI) handlers are installed here and the task cycle timing (i.e., 400Hz tasks, 200Hz tasks ...etc.) is set up. Finally the configurator hands control off to the task manager after all of the items have been instantiated and their various parameters are set up.

### 3.1.2.1.12 Error Detection and Correction

NISTAR has built-in EDAC hardware, which is used to maintain SRAM. By frequently reading through memory (known as scrubbing), any single-bit errors (the most common type of error) will be corrected by the EDAC hardware and will help prevent accumulation into multi-bit errors. Multi-bit errors cannot be corrected but are reported indirectly through telemetry. Most multi-bit errors are not due to physical damage to the memory cell. It is mostly due to the deposition of energy in the memory cell from a passing high-energy particle. When a multi-bit error occurs, it can lead to an erroneous memory value being used by the software. Multi-bit errors are usually cleared on the next scrub pass through the affected memory location. However, if there is some damage to the SRAM in a particular area, EDAC will find and report a multi-bit error every time that memory area is scrubbed. To circumvent a flood of EDAC error reporting there exists the ability to “skip” scrubbing that area of memory by creating a new scrub segment.

This scrubbing task has a number of segments associated with it. Each segment is a particular address range to scrub. Initially there is only one segment comprising the entire RAM space. The other segments (and the ability to create and destroy segments) are in place in case there is a hardware problem which causes a particular address range to no longer have functioning EDAC (causing the processor to get overrun with EDAC errors for no real reason), or in case it is



determined on orbit (due to some unforeseen circumstance) that additional address ranges need to be scrubbed, or that particular address ranges that are already being scrubbed should not be. For example, if the address is X where there is perpetually an error, the main scrubber can be stopped, and two new scrubbers started ... one from 0x100 to X-4, and the second from X+4 to 0x7FFFFF. This action will eliminate address X from the scrub, and the constant errors will not recur.

The EDAC error handling process is described here further. A DSI occurs whenever there is a bus failure while attempting a data access. There are several reasons for such a failure, the most serious being a multi-bit EDAC error. When a DSI failure occurs, an Interrupt Service Routine (ISR) is called that retries the access. In general the EDAC hardware will make a best-guess at the data value on the first read attempt and store it in the RAM that is being scrubbed, causing the retry to collect some data, of possibly an erroneous value. If the second access fails, or it is not possible to retry the access, the same best guess will occur, but the error will be counted as a DSI failure, and an erroneous data value becomes the result of the access. The memory is repeatedly "scrubbed" by reading through all of the locations. This action will, in general, cause any EDAC errors to be manifested as data accesses.

An explanation of the EDAC telemetry is listed in Table 3-14.

**Table 3-14. EDAC Telemetry**

| <b>Mnemonic</b>                           | <b>Description</b>                                                                                                                                                                                                                       |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NILSDSIADD – Last DSI Address             | The physical address of the data access which caused the most recent DSI.                                                                                                                                                                |
| NILSDSITID – Last DSI Transfer Identifier | The transfer identifier of the last data access which caused the most recent DSI. This identifier indicates information about the transfer.                                                                                              |
| NITOTDSIFAIL – Total DSI Failures         | The total number of unrecoverable DSIs which have occurred.                                                                                                                                                                              |
| NISTARTSEG – Start Segment                | Indicates the segment number of the currently reported segment status telemetry. There are ten available scrub segments and the telemetry rotates through their statuses in a monotonic pattern. Two segments are reported on at a time. |





| <b>Mnemonic</b>                       | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIMSSTATUS – Memory Scrub Status      | Indicates the status of the two reported segments. Each segment has two bits in the status word corresponding to its ordinal number times two, with bit 0 being the least significant bit in the word (so segment 1 will occupy bits 2 and 3). The bit patterns have the following meanings:<br>00 Segment is inactive<br>01 Segment is active and operating properly<br>10 Segment is active and has experienced some sort of error<br>11 reserved |
| NISEG0START – Segment 0 Start Address | Indicates the starting address (inclusive) of the first of the two currently reported segment's scrub area.                                                                                                                                                                                                                                                                                                                                         |
| NISEG0FIN - Segment 0 Finish Address  | Indicates the ending address (inclusive) of the first of the two currently reported segment's scrub area.                                                                                                                                                                                                                                                                                                                                           |
| NISEG0ITER – Segment 0 Iterations     | Indicates the number of scrub iterations over the first of the two currently reported segment's scrub area that have occurred.                                                                                                                                                                                                                                                                                                                      |
| NISEG1START – Segment 1 Start Address | Indicates the starting address (inclusive) of the second of the two currently reported segment's scrub area.                                                                                                                                                                                                                                                                                                                                        |
| NISEG1FIN – Segment 1 Finish Address  | Indicates the ending address (inclusive) of the second of the two currently reported segment's scrub area.                                                                                                                                                                                                                                                                                                                                          |
| NISEG1ITER – Segment 1 Iterations     | Indicates the number of scrub iterations over the second of the two currently reported segment's scrub area that have occurred.                                                                                                                                                                                                                                                                                                                     |

There are two commands that are associated with EDAC. Their description follows.

**NIACSEG** - This command will activate a portion of memory (by segment number) to be scrubbed by EDAC. To be sent when: upon examination of the error values, the EDAC appears to be broken, if there is a segment of memory for which the EDAC is not functioning properly, or some

unforeseen event requires that the scrubber operations be altered. User inputs the start and finish address that will be associated with the segment number. Currently, the entire ram space is one large segment with segment number 0.

**NIDEACSEG** - This command will deactivate a portion of memory (by segment number) from being scrubbed by EDAC. To be sent when: upon examination of the error values, the EDAC appears to be broken, if there is a segment of memory for which the EDAC is not functioning properly, or some unforeseen event requires that the scrubber operations be altered.





### 3.2 NISTAR POWER OVERVIEW

The DSCOVN Power Node contains the relay that controls power supply to the NISTAR instrument. The command to enable power to the NISTAR instrument is /PNNISTARPWR ENABLE. To disable power the command is /PNNISTARPWR DISABLE. The status of this relay is telemetered in mnemonic PNNISTARPWR and has values of "ON" and "OFF".

NISTAR contains a power converter to condition and isolate the power required for all of the NISTAR components. The converter is shielded and filtered to reduce conducted and common mode Electromagnetic Interference (EMI) in the system. The converter is capable of regulating the +28Volt (V) spacecraft power supply to  $\pm 15V$ , +5V, and +3.3V.

Currently, NISTAR draws approximately 1.5Amps (A) of current when powered and in Science mode. The shutter and filter wheel motor currents are typically 0A when not moving and 100milliAmps (mA) when moving. These currents can be read in the telemetry mnemonics listed in Table 3-15.

**Table 3-15. Power Telemetry**

| Mnemonic     | Description                                                         |
|--------------|---------------------------------------------------------------------|
| PNNISTARCUR  | NISTAR Current as telemetered by the DSCOVN Power Node<br>Units = A |
| NIFWPHAMTRI  | Filter Wheel Phase A Motor Current<br>Units = mA                    |
| NIFWPHBMTRI  | Filter Wheel Phase B Motor Current<br>Units = mA                    |
| NIPDPHAMTRI  | Photodiode Shutter Phase A Motor Current<br>Units = mA              |
| NIPDPHBMTRI  | Photodiode Shutter Phase B Motor Current<br>Units = mA              |
| NIRC1PHAMTRI | Receiver Cavity 1 Shutter Phase A Motor Current<br>Units = mA       |
| NIRC1PHBMTRI | Receiver Cavity 1 Shutter Phase B Motor Current<br>Units = mA       |
| NIRC2PHAMTRI | Receiver Cavity 2 Shutter Phase A Motor Current<br>Units = mA       |
| NIRC2PHBMTRI | Receiver Cavity 2 Shutter Phase B Motor Current<br>Units = mA       |
| NIRC3PHAMTRI | Receiver Cavity 3 Shutter Phase A Motor Current<br>Units = mA       |



| Mnemonic     | Description                                                   |
|--------------|---------------------------------------------------------------|
| NIRC3PHBMTRI | Receiver Cavity 3 Shutter Phase B Motor Current<br>Units = mA |

### 3.3 NISTAR THERMAL OVERVIEW

The ICE and RA are thermally isolated from the spacecraft. Passive radiators are installed on the ICE to disperse the electronics heat load (maximum of 35Watts [W]). The RA includes a thermal bench heater, which maintains the HS temperature.

The NISTAR operational heaters are powered through the NISTAR +28V power relay. The current that these heaters draw is part of the power node telemetered NISTAR current (PNNISTARCUR.)

The NISTAR survival heaters are powered through the NISTAR Survival Heater Safety Inhibit Unit (SIU) relay. There is no telemetry from the SIU, so the state of this relay cannot be seen in telemetry. The normal SIU separation timeline does not disable the inhibit that prevents this relay from being closed. Therefore, to enable power to the NISTAR survival heaters, the SIU inhibit must be manually disabled. This can be done by sending the command /rawtf 304E000600F8CC. To reapply the inhibit the command is /rawtf 304E000600F865. These commands can be sent by using the SIUCMD ITOS page to start the SIU\_CMD.PROC STOL procedure that sends the appropriate commands. The current that the NISTAR survival heaters draws is part of the Heater Bus 2 current, which is telemetry mnemonic PNHTRBUS2CUR.



## 4.0 NISTAR OPERATIONS

Normal NISTAR operations and calibrations will be commanded via on-board scripts in the C&DH. The complete list of NISTAR commands are presented and explained in Appendix D.

### 4.1 POWER-ON

The STOL procedure that is used for NISTAR power-on is **NIST\_PWR\_ON.PROC**. This procedure should be used during operations and during I&T to power on the NISTAR instrument. All steps of the procedure should be followed. The procedure does the following:

- Checks to make sure that the DSCOVN Comphub software is in Normal mode. NISTAR should not be powered on if the Comphub software mode is boot because the payload manager task that is used to communicate with the instruments is not running in boot mode, only normal mode. This means if NISTAR is powered in boot mode, no telemetry will be seen from the instrument and the payload manager task will not forward commands to NISTAR.
- Checks to make sure that the AOCS software mode is not Safehold. NISTAR should not be powered on in Safehold mode. If it is powered a safing script will run which will turn it off immediately. Safehold is considered a contingency mode, so all instruments are powered off in this mode to conserve power.
- Checks NISTAR power relay. If the relay is already on, the procedure is exited. If the relay is off it is turned on.
- Two configuration monitors are then started on the ITOS system. They are called nipdcurr and nittime. They are explained in Section 4.3.
- The RC shutters and filter wheel are then calibrated by command one by one. This is done so that the software knows what position the shutters are in and they can be moved safely during operation.
- The instrument software mode is then commanded to Science mode.
- The instrument is then commanded to perform ADC, PTC and Heater Calibrations. These calibrations are explained further in section 4.1.1.
- All overruns are cleared by command. Overruns are normally produced during the instrument software boot-up.
- The NISTAR general configuration monitor, called nistar, is started. This configuration monitor is explained in Section 4.3.
- The procedure is exited.

#### 4.1.1 Calibrations

The ADC calibration is an internal calibration to the ADC chip that is used to measure the bridge error signal in the receiver/heat sink temperature sensor resistance measurement circuit. The chip goes through an internal voltage scale calibration.

The PTC calibration is used to adjust the resistance reading of the temperature sensor resistance measurement. A relay is activated which switches into the circuit a precision 20kOhm resistor in



place of the PTC temperature sensor. The circuit is then adjusted in flight software for both gain and offset errors.

**NISTARTCAL** - This command will activate the specified ADC, PTC or Heater calibration for the specified RC or HS. The user can also choose to perform all calibrations on all RCs and the HS with this command.

## 4.2 NORMAL OPERATIONS

NISTAR's mode of operations has the shutters for the RCs cycling on a 10 minute rotations. The Shutters will open to position 198 for 5 minutes then close to position 2 for another 5 minutes. Normal configuration has the filter wheel in position 3. This autocycle operation is internal commanded by NISTAR SW. The proc NIST\_SHUTR\_AUTOCYCLE is used to set the cycle time and shutters that are to be cycled.

It should be noted that while autocycle is on, shutter commands will not be processed by the Instruments software. A command error will be reported if a shutter command is sent while autocycle is on.

NISTAR autocycle is disabled every 7 days to cycle the SiPD shutter. The SiPD Shutter is closed for 5 minutes and then reopened. Autocycle is resumed on the nominal 10 min cycle.

## 4.3 POWER-OFF

The STOL procedure that is used for NISTAR power-off is NIPWRDOWN.PROC. This procedure should be used during operations and during I&T to power off the NISTAR instrument. All steps of the procedure should be followed. The procedure does the following:

- The NISTAR general configuration monitor, nistar, is cleared on the ITOS system. This is done first because part of the power down process will cause configuration monitor violations if the configuration monitor is running.
- The instrument software mode is commanded to Maintenance/Safe mode. This is done so that all of the shutters are closed before removing power from the instrument.
- The procedure waits 5 seconds. This gives the instrument time to close all of the shutters.
- The nipdcrr and nittime configuration monitors are cleared on the ITOS system.
- NISTAR power is then removed by commanding the power node NISTAR relay to disabled.

**Note:** It is very important that the NISTAR shutters are closed before power is removed. If the shutters remain open while the instrument is unpowered, contamination of the receiver cavities is possible. Executing this STOL NISTAR power down procedure insures that the shutters are closed. Never command the NISTAR relay by hand to disabled unless you are absolutely sure that the shutters are closed.



#### 4.4 CONFIGURATION MONITORS

Three configuration monitors exist for NISTAR that are necessary for operations. These configuration monitors should always be running on any ITOS workstation that is being used to view NISTAR telemetry while the instrument is powered. These configuration monitors are started on the command terminal system automatically by the STOL NIPWRUP.PROC procedure but must be started on any other system by hand. The configuration monitors are explained below.

- nipdcurr – This configuration monitor must be run to calculate the PD current. The Photodiode ADC Average 10Hz samples and the Photodiode DAC Average 10Hz samples (there are ten of each) telemetry mnemonics are mathematically manipulated within the configuration monitor and the outputs are written to ground mnemonics to be displayed. The calculations are performed once a second. The telemetry mnemonics and ground mnemonics associated with this configuration monitor are listed in Table 4-1.

**Table 4-1. NIPDCURR Configuration Monitor Related Telemetry**

| Mnemonic         | Description                                                                                           |
|------------------|-------------------------------------------------------------------------------------------------------|
| NIPDDACAVG10HZ1  | Photodiode DAC Average 10Hz Sample 1                                                                  |
| NIPDDACAVG10HZ2  | Photodiode DAC Average 10Hz Sample 2                                                                  |
| NIPDDACAVG10HZ3  | Photodiode DAC Average 10Hz Sample 3                                                                  |
| NIPDDACAVG10HZ4  | Photodiode DAC Average 10Hz Sample 4                                                                  |
| NIPDDACAVG10HZ5  | Photodiode DAC Average 10Hz Sample 5                                                                  |
| NIPDDACAVG10HZ6  | Photodiode DAC Average 10Hz Sample 6                                                                  |
| NIPDDACAVG10HZ7  | Photodiode DAC Average 10Hz Sample 7                                                                  |
| NIPDDACAVG10HZ8  | Photodiode DAC Average 10Hz Sample 8                                                                  |
| NIPDDACAVG10HZ9  | Photodiode DAC Average 10Hz Sample 9                                                                  |
| NIPDDACAVG10HZ10 | Photodiode DAC Average 10Hz Sample 10                                                                 |
| NIPDADCAVG10HZ1  | Photodiode ADC Average 10Hz Sample 1                                                                  |
| NIPDADCAVG10HZ2  | Photodiode ADC Average 10Hz Sample 2                                                                  |
| NIPDADCAVG10HZ3  | Photodiode ADC Average 10Hz Sample 3                                                                  |
| NIPDADCAVG10HZ4  | Photodiode ADC Average 10Hz Sample 4                                                                  |
| NIPDADCAVG10HZ5  | Photodiode ADC Average 10Hz Sample 5                                                                  |
| NIPDADCAVG10HZ6  | Photodiode ADC Average 10Hz Sample 6                                                                  |
| NIPDADCAVG10HZ7  | Photodiode ADC Average 10Hz Sample 7                                                                  |
| NIPDADCAVG10HZ8  | Photodiode ADC Average 10Hz Sample 8                                                                  |
| NIPDADCAVG10HZ9  | Photodiode ADC Average 10Hz Sample 9                                                                  |
| NIPDADCAVG10HZ10 | Photodiode ADC Average 10Hz Sample 10                                                                 |
| NIPDCURRS1       | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ1 and NIPDDACAVG10HZ1. |
| NIPDCURRS2       | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ2 and NIPDDACAVG10HZ2. |
| NIPDCURRS3       | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ3 and NIPDDACAVG10HZ3. |



| <b>Mnemonic</b> | <b>Description</b>                                                                                      |
|-----------------|---------------------------------------------------------------------------------------------------------|
| NIPDCURRS4      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ4 and NIPDDACAVG10HZ4.   |
| NIPDCURRS5      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ5 and NIPDDACAVG10HZ5.   |
| NIPDCURRS6      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ6 and NIPDDACAVG10HZ6.   |
| NIPDCURRS7      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ7 and NIPDDACAVG10HZ7.   |
| NIPDCURRS8      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ8 and NIPDDACAVG10HZ8.   |
| NIPDCURRS9      | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ9 and NIPDDACAVG10HZ9.   |
| NIPDCURRS10     | Ground mnemonic that holds the result of the calculation between NIPDADCAVG10HZ10 and NIPDDACAVG10HZ10. |

- nitime – The NISTAR instrument software provides the instrument time since boot-up in two telemetry mnemonics, NIINSTTIME1 and NIINSTTIME2. These two mnemonics must be mathematically manipulated on the ground, by configuration monitor nitime, to convert the values of the two mnemonics to a value of seconds. The output of the math is written to the ground mnemonic NIINSTTIME once a second. NIINSTTIME contains the value of the number of seconds since NISTAR software boot (or power-on.)
- nistar – This configuration monitor will alert the user to any BIT failures and any overruns that have occurred. It will also alert the user to any uncalibrated motors or rejected NISTAR commands. The user will also be alerted if an autosafe has occurred, or if the software mode is Maintenance/Safe. This configuration monitor is evaluated once a second.

#### 4.5 INSTRUMENT SAFING

Because of the fear of contamination, NISTAR should be commanded to maintenance/safe mode before and during thruster firings if it is powered.

The C&DH software runs several scripts that are used for spacecraft safing. These scripts will take action by calling other scripts to command spacecraft systems or will send commands to spacecraft systems themselves.

A script named INPWRDOWN will send commands to close all four of NISTAR's shutters, waits an adequate amount of time for them to complete closing (~ 5 seconds), and then disables the NISTAR power relay. The shutters are closed to prevent contamination while the instrument is not being used. This script is started from other scripts if certain conditions are met. The scripts that call the



INPWRDOWN script and other safing scripts that involve NISTAR are discussed in the next sections. Refer to the DSCOVN SAFING SPECIFICATION, DSCOVN-SPEC-049 for updated instrument safing information.

#### 4.5.1 PBATSAFE Safing Script

The PBATSAFE script was designed to detect a low battery state of charge, a very low battery state of charge, a battery undervoltage, a spacecraft power management current control loop failure, and a spacecraft power management voltage control loop failure. The PBATSAFE safing conditions and actions that involve NISTAR are listed in Table 4-2.

**Table 4-2. PBATSAFE Safing Script Details**

| Condition Name                    | Condition Specifications                                                                                           | Safing Action                                                                               |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Low battery state of charge (SOC) | Battery SOC < 70% AND amp-hour integrator (AHI) enabled                                                            | Start INPWRDOWN                                                                             |
| Battery high discharge current    | Battery discharge current exceeds 9Amps for greater than 2 minutes                                                 | Start INPWRDOWN                                                                             |
| Battery undervoltage              | (Battery Top-half voltage) < (Undervoltage Threshold) OR (Battery bottom-half voltage) < (Undervoltage Threshold). | Start INPWRDOWN<br>Place spacecraft in Safehold and re-initialize power management software |

#### 4.5.2 PCURSAFE Safing Script

The PCURSAFE script was designed to detect an EPIC overcurrent condition, a NISTAR overcurrent condition, a PlasMag overcurrent condition, and a transmitter overcurrent condition. The PCURSAFE safing conditions and actions that involve NISTAR are listed in Table 4-3.

**Table 4-3. PCURSAFE Safing Script Details**

| Condition Name     | Condition Specifications                           | Safing Action                                                                                                                                              |
|--------------------|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NISTAR Overcurrent | NISTAR current exceeds 2 times the nominal current | The PCURSAFE script will send commands to close all NISTAR shutters, waits ~ 5 seconds for them to close, then disables the NISTAR power relay by command. |

#### 4.5.3 SAFEHOLD Safing Script

The SAFEHOLD script was designed to disable the instrument buses when the spacecraft Attitude and Orbit Control System (AOCS) mode is Safehold and prevent them from being turned on while in





that mode. When we are in Safehold, we are assuming something anomalous happened and we want to go to our lowest power usage. If this script detects NISTAR is on and the AOCS mode is Safehold, it will send commands to close all NISTAR shutters, wait 5 seconds for them to close, and then disable power to the NISTAR instrument.

The SAFEHOLD safing script is called if high body rates are detected among other reasons.

#### **4.5.4 On-Orbit Calibration Operations**

NISTAR will undergo several different calibration operations on orbit. They are described below.

A Moon view calibration will be performed nominally once a month. This calibration will coincide with the EPIC Lunar calibrations. The Moon view calibration involves slewing the observatory to view the Moon. Its purpose is to track the degradation of the SiPD due to outgassing. In order to collect data for the SiPD channel and the various filters, approximately 15 minutes of collection time will be required. For measurements of the Lunar flux with the receiver channels several hours of time will be required.

A shutter/cavity inside surface calibration will be performed once a week for the first six months on orbit and then monthly. The observatory will be slewed off of the Earth for a space view. The instrument will then take measurements with the shutters open and no filters in view. The purpose is to determine what the zero energy flux is on the instrument. This calibration will take several hours and can coincide with the EPIC Space View Calibration.

An intercomparison of the total flux from the three RCs and the SiPD will be performed once a week for the first six months and then once per month. This involves positioning the filters in the open position so that the cavities are in direct view of the Earth. Theoretically, all cavities should measure the same signal. Any differences in the measurements will provide a comparison between cavities. This calibration will last approximately 16 hours.

Two types of filter comparison calibrations will be performed. A rapid intercomparison of filter transmission using the photodiode will be performed once a month and takes approximately 15 minutes to complete. This calibration involves rotating all the filters in front of the SiPD and observing any changes between filters. Another filter intercomparison measurement will be performed once a month and takes approximately 20 hours. This calibration involves rotating the filters in front of each receiver cavity to make comparisons between receiver cavities.





**Appendix A. Acronym List**

| <b>Acronym</b> | <b>Description</b>                                                 |
|----------------|--------------------------------------------------------------------|
| A              | Amperes                                                            |
| ADC            | Analog/Digital Converter                                           |
| AHI            | Amp Hour Integrator                                                |
| AOCS           | Attitude and Orbit Control System                                  |
| BIT            | Built-In-Test                                                      |
| bps            | Bits per second                                                    |
| CompHub        | DSCOVN Computational Hub                                           |
| CPU            | Central Processing Unit                                            |
| C&DH           | Command and Data Handling                                          |
| DSI            | Data Storage Interrupt                                             |
| EDAC           | Error Detection and Correction                                     |
| EMI            | Electromagnetic Interference                                       |
| EPIC           | Earth Polychromatic Imaging Camera                                 |
| FOR            | Field of Regard                                                    |
| FOV            | Field of View                                                      |
| FPGA           | Focal Plane Gate Array                                             |
| FW             | Filter Wheel                                                       |
| GMT            | Greenwich Mean Time                                                |
| HS             | Heat Sink                                                          |
| Hz             | Hertz                                                              |
| ICE            | Interface Control Electronics                                      |
| ID             | Identification                                                     |
| ISR            | Interrupt Service Routine                                          |
| ITOS           | Integrated Test and Operations System                              |
| I&T            | Integration and Test                                               |
| I/O            | Input/Output                                                       |
| L1             | Lagrange-1                                                         |
| MB             | Megabytes                                                          |
| MHz            | Megahertz                                                          |
| NISTAR         | National Institute of Standards and Technology Advanced Radiometer |
| PD             | Silicon Photodiode                                                 |
| PID            | Proportional Integral Derivative                                   |
| PlasMag        | Plasma Magnetometer                                                |
| PTC            | Positive Temperature Coefficient                                   |
| QHSS           | Quad High Speed Serial                                             |
| RA             | Radiometer Assembly                                                |
| RAM            | Random Access Memory                                               |
| RC             | Receiver Cavity                                                    |
| RT             | Remote Terminal                                                    |
| SC             | Subsystem Control                                                  |
| SD             | Silicon Photodiode                                                 |
| SiPD           | Silicon Photodiode                                                 |
| SOC            | State of Charge                                                    |

A-1

CHECK WITH DSCOVN DATABASE AT:

<https://dscovr-ngin.ndc.nasa.gov>

TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE



Distributed by the Atmospheric Science Data Center  
<http://eosweb.larc.nasa.gov>



| <b>Acronym</b> | <b>Description</b>                         |
|----------------|--------------------------------------------|
| SRAM           | Static Read Access Memory                  |
| SSR            | Solid State Recorder                       |
| STOL           | Spacecraft Testing and Operations Language |
| TSC            | DSCOVER Spacecraft                         |
| UART           | Universal Asynchronous Receive/Transmit    |
| V              | Volts                                      |
| VC             | Virtual Channel                            |
| W              | Watts                                      |
| XOR            | Exclusive Or                               |
| 1553           | MIL-STD-1553                               |



## Appendix B. NISTAR Memory Map

### RAM Segment 0x0 (Memory Row 0,1,2 and 3)

Size = 4 Mbytes

|                    |                                                         |                                                                            |
|--------------------|---------------------------------------------------------|----------------------------------------------------------------------------|
| 0x00000000         | <b>SUROM Status</b>                                     |                                                                            |
| 0x00000100         | <b>Interrupt Vector Table</b>                           |                                                                            |
| 0x00002000         | <b>SUROM Workspace</b>                                  |                                                                            |
| 0x00002700         | <b>Boot Parameters, Boot Line</b>                       |                                                                            |
| 0x00003000         | <b>Device Driver Buffers</b>                            |                                                                            |
| 0x00008000         | <b>Hash Allocation Table</b>                            | HAT_ADRS = 0x00008000                                                      |
| 0x00010000         | <b>Page Frame Table</b>                                 | PFT_ADRS = 0x00010000                                                      |
| 0x00020000         | <b>Unused</b>                                           |                                                                            |
| 0x00030000         | <b>System Data Save (saved values for warm restart)</b> | SAVE_SYS_DATA_ADRS = 0x30000<br>SAVE_SYS_DATA_SIZE = 0x20000<br>0x0004FFFF |
| 0x00050000         | <b>Code</b>                                             | RAM_LOW_ADDR = 0x00050000                                                  |
| -----              |                                                         |                                                                            |
| <b>vxWorks</b>     | <b>Data and Objects</b>                                 |                                                                            |
| +                  |                                                         |                                                                            |
| -----              |                                                         |                                                                            |
| <b>Application</b> | <b>Heap</b>                                             |                                                                            |
| +                  | ↓                                                       |                                                                            |
| <b>Data</b>        |                                                         |                                                                            |
|                    | ↑                                                       |                                                                            |
|                    | <b>Stack</b>                                            | LOCAL_MEM_SIZE = 0x00700000                                                |
|                    |                                                         | 0x0003FFFF                                                                 |

B-1

CHECK WITH DSCOVN DATABASE AT:

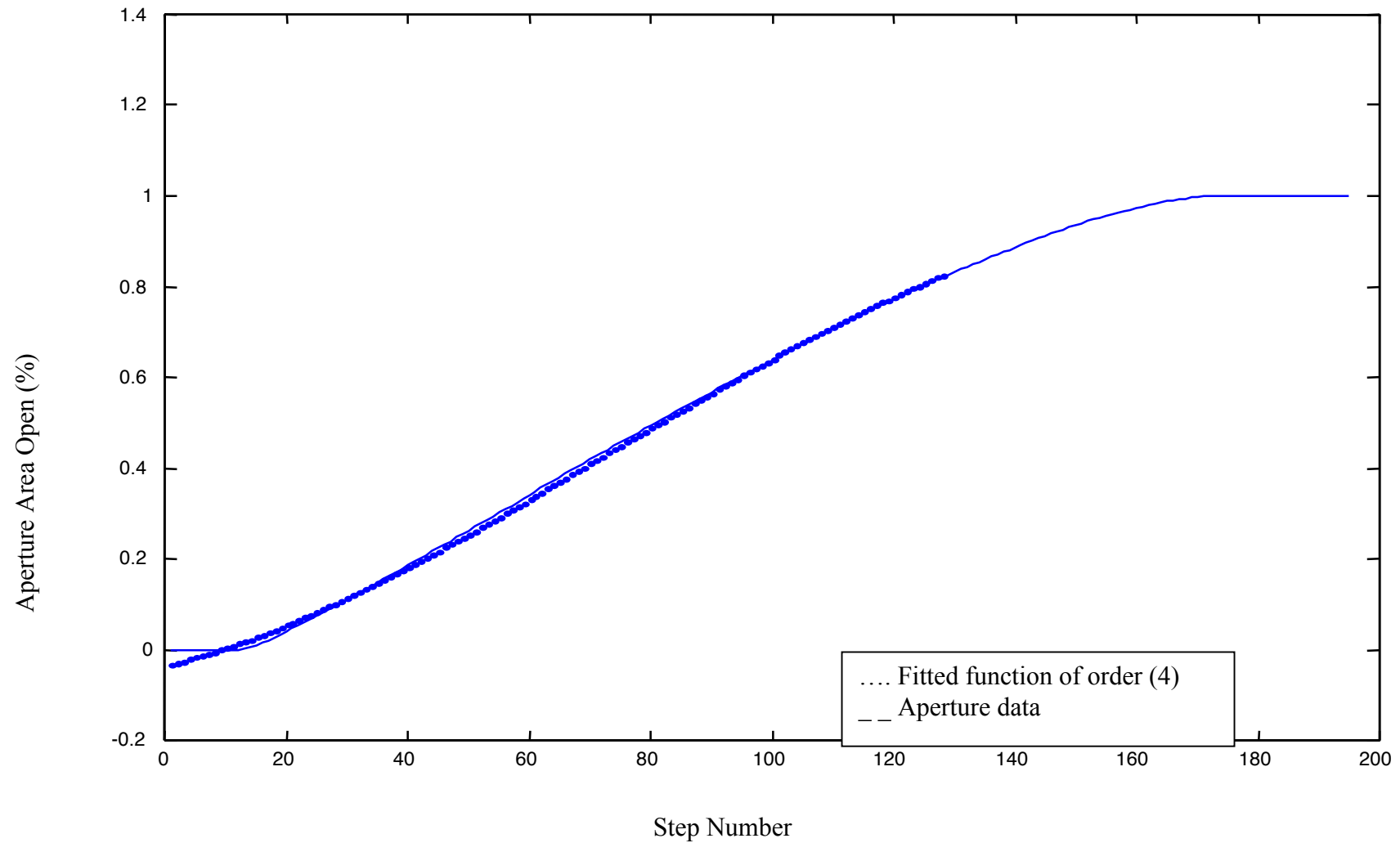
<https://dscovr-ngin.ndc.nasa.gov>

TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE



Distributed by the Atmospheric Science Data Center  
<http://eosweb.larc.nasa.gov>



**Appendix C. Shutter Aperture Area Function**

C-1

CHECK WITH DSCOVN DATABASE AT:  
<https://dscovr-ngin.ndc.nasa.gov>  
TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

**Appendix D. NISTAR Command List**

| Function Code | Command    | Description                                                                                                                                                                                        | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                                                                                                 | Telemetry for Commanded Value |
|---------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| 0             | NINOOP     | Instrument no-operation command.                                                                                                                                                                   | all                                                          |                                                                                                                                                                                                                     | NICMDCNT increments by one    |
| 1             | NIINSTMODE | Toggles the instrument mode to either Science or Maintenance/Safe - User specified. Commanding the instrument to the same mode that it is in has no effect on the instrument software or hardware. | all                                                          | Mode commanding must be armed (Mnemonic NIMODECMD = "ARMED")<br><br>Commanding the instrument to maintenance/safe mode closes any shutters that are open. The filter wheel will not move from its current position. | NIINSTMODE                    |
| 2             | NIMODECMD  | Arms or disarms instrument mode commanding.                                                                                                                                                        | all                                                          | Mode commanding is automatically disarmed if maint/safe mode is entered automatically.                                                                                                                              | NIMODECMD                     |

| Function Code | Command     | Description                                                                                                       | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints | Telemetry for Commanded Value                                                                                                                                                                                                                                                                                    |
|---------------|-------------|-------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3             | NICMDRESET  | Resets the accept and reject command counters. It also resets the software overrun errors.                        | all                                                                      |                        | After reset:<br>NICMDCNT=1<br>NIERRCNT = 0<br>NIMMMDOR = NO OVERRUNS<br>NISCFPGAOR = NO OVERRUNS<br>NISCFWOR = NO OVERRUNS<br>NISCHTROR = NO OVERRUNS<br>NISCPDOR = NO OVERRUNS<br>NISCSHTROR = NO OVERRUNS<br>NISCTSCOR = NO OVERRUNS<br>NITSKMGROR = NO OVERRUNS<br>NITSKORCNT =0 for all Task IDs (NITSKORID) |
| 4             | NIPTC       | Sets the desired PTC resistance (temperature) when running closed loop temperature control for selected RC or HS. | Science                                                                  |                        | NIHSPTCRSP<br>NIRC1PTCRSP<br>NIRC2PTCRSP<br>NIRC3PTCRSP                                                                                                                                                                                                                                                          |
| 5             | NIFOPRECHRG | Sets the Fixed Open Precharge Value for the Drop Floor Algorithm for specified RC and Filter Type.                | Science                                                                  |                        | NIRC1FOPRECHRG<br>NIRC2FOPRECHRG<br>NIRC3FOPRECHRG<br>NIRC1FOPRECHRGB<br>NIRC2FOPRECHRGB<br>NIRC3FOPRECHRGB<br>NIRC1FOPRECHRC<br>NIRC2FOPRECHRC<br>NIRC3FOPRECHRC                                                                                                                                                |

| Function Code | Command      | Description                                                                                                                                  | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints | Telemetry for Commanded Value                                                                                                                                     |
|---------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6             | NIFCPRECHRG  | Sets the Fixed Close Precharge Value for the Drop Floor Algorithm for specified RC and Filter Type.                                          | Science                                                                  |                        | NIRC1FCPRECHRG<br>NIRC2FCPRECHRG<br>NIRC3FCPRECHRG<br>NIRC1FCPRECHRGB<br>NIRC2FCPRECHRGB<br>NIRC3FCPRECHRGB<br>NIRC1FCPRECHRG<br>NIRC2FCPRECHRG<br>NIRC3FCPRECHRG |
| 7             | NIPRECHRGMOD | Sets the software to use the fixed precharge value, the automated precharge mode, or disable the floor / guess for selected receiver cavity. | Science                                                                  |                        | NIRC1PRECHRGMOD<br>NIRC2PRECHRGMOD<br>NIRC3PRECHRGMOD                                                                                                             |
| 8             | NIPID2P      | Sets the tuning parameter PID2 P for selected RC, HS, or PD.                                                                                 | Science                                                                  |                        | NIPDPID2P<br>NIHSPID2P<br>NIRC1PID2P<br>NIRC2PID2P<br>NIRC3PID2P                                                                                                  |
| 9             | NIPID2I      | Sets the tuning parameter PID2 I for selected RC, HS, or PD.                                                                                 | Science                                                                  |                        | NIPDPID2I<br>NIHSPID2I<br>NIRC1PID2I<br>NIRC2PID2I<br>NIRC3PID2I                                                                                                  |
| 10            | NIPID2D      | Sets the tuning parameter PID2 D for selected RC, HS, or PD.                                                                                 | Science                                                                  |                        | NIPDPID2D<br>NIHSPID2D<br>NIRC1PID2D<br>NIRC2PID2D<br>NIRC3PID2D                                                                                                  |

| Function Code | Command    | Description                                                                                 | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints                      | Telemetry for Commanded Value                                    |
|---------------|------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------|------------------------------------------------------------------|
| 11            | NIPID2K    | Sets the tuning parameter PID2 K Loop for selected RC, HS, or PD.                           | Science                                                                  |                                             | NIPDPID2K<br>NIHSPID2K<br>NIRC1PID2K<br>NIRC2PID2K<br>NIRC3PID2K |
| 12            | NISINWVFRQ | Sets the Sine Wave Frequency Value for selected RC or HS.                                   | Science                                                                  | Frequency value must be between 35 and 155. | NIHSSINWVFRQ<br>NIRC1SINWVFRQ<br>NIRC2SINWVFRQ<br>NIRC3SINWVFRQ  |
| 13            | NITEMPCTRL | Opens or Closes the temperature control loop for selected RC or HS.                         | Science                                                                  |                                             | NIHSTEMPCTRL<br>NIRC1TEMPCTRL<br>NIRC2TEMPCTRL<br>NIRC3TEMPCTRL  |
| 14            | NIDIFFMODE | Selects the control loop mode for the selected RC.                                          | Science                                                                  |                                             | NIRC1DIFFMODE<br>NIRC2DIFFMODE<br>NIRC3DIFFMODE                  |
| 15            | NIHSOLPWR  | Set the desired output power when running in open loop temperature control mode for the HS. | Science                                                                  |                                             | NIHSCMDOLPWR                                                     |
| 15            | NIRC1OLPWR | Set the desired output power when running in open loop temperature control mode for RC1.    | Science                                                                  |                                             | NIRC1CMDOLPWR                                                    |
| 15            | NIRC2OLPWR | Set the desired output power when running in open loop temperature control mode for RC2.    | Science                                                                  |                                             | NIRC2CMDOLPWR                                                    |



| Function Code | Command     | Description                                                                                                                                                                                                                                                      | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints                                                                                                                                                                                                       | Telemetry for Commanded Value                                                                                                                                                                         |
|---------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15            | NIRC3OLPWR  | Set the desired output power when running in open loop temperature control mode for RC3.                                                                                                                                                                         | Science                                                                  |                                                                                                                                                                                                                              | NIRC3CMDOLPWR                                                                                                                                                                                         |
| 16            | NISTARTCAL  | Starts the selected calibration procedure(s) (All, ADC, PTC, HTR) for selected RC or HS. Note: If selected, "All" calibration procedures and "ADC" calibrations will be executed for all four heaters (RC1, RC2, RC3, and HS.) regardless of RC or HS selection. | Science                                                                  |                                                                                                                                                                                                                              | NIHSADCCALST<br>NIRC1ADCCALST<br>NIRC2ADCCALST<br>NIRC3ADCCALST<br>NIHSHTRCALST<br>NIRC1HTRCALST<br>NIRC2HTRCALST<br>NIRC3HTRCALST<br>NIHSPTCCALST<br>NIRC1PTCCALST<br>NIRC2PTCCALST<br>NIRC3PTCCALST |
| 17            | NIMVSHUTTER | Moves selected shutter (RC or PD) to selected position.                                                                                                                                                                                                          | Science                                                                  | Valid positions are 0 to 200. Any value outside of the 2-198 range will cause the physical limit switches to be hit by the shutter.<br><br>This command will fail if the motor of another shutter or filter wheel is moving. | NIRC1PRESHPOSNUM<br>NIRC2PRESHPOSNUM<br>NIRC3PRESHPOSNUM<br>NIPDPRESHPOSNUM                                                                                                                           |

| Function Code | Command     | Description                                                             | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                                                                                                                     | Telemetry for Command Value                                                 |
|---------------|-------------|-------------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 17            | NICLOSESHUT | Moves the selected shutter to position 2, which is the closed position. | Science                                                      | Selected shutter must be calibrated (NIRC1CAL, NIRC2CAL, NIRC3CAL, or NIPDCAL = "CALIBRATED") so that the software knows where position 2 is located. This command will fail if the motor of another shutter or filter wheel is moving. | NIRC1PRESHPOSNUM<br>NIRC2PRESHPOSNUM<br>NIRC3PRESHPOSNUM<br>NIPDPRESHPOSNUM |
| 17            | NIOPENSHUT  | Moves the selected shutter to position 198, which is the open position. | Science                                                      | Selected shutter must be calibrated (NIRC1CAL, NIRC2CAL, NIRC3CAL, or NIPDCAL = "CALIBRATED") so that the software knows where position 2 is located. This command will fail if the motor of another shutter or filter wheel is moving. | NIRC1PRESHPOSNUM<br>NIRC2PRESHPOSNUM<br>NIRC3PRESHPOSNUM<br>NIPDPRESHPOSNUM |

| Function Code | Command      | Description                                                                                                                                                                                            | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                                        | Telemetry for Commanded Value                                               |
|---------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 18            | NIINTSHTRPOS | Sets the internal software position of the selected shutter (RC or PD). This command does not physically move the shutter. It only sets the position where the software thinks the shutter is located. | Science                                                      | Valid positions are 0 - 200. The Built-In-Test (BIT) status of selected shutter must be "PASS" in order for the software to accept the command.            | NIRC1PRESHPOSNUM<br>NIRC2PRESHPOSNUM<br>NIRC3PRESHPOSNUM<br>NIPDPRESHPOSNUM |
| 19            | NIMVWHEEL    | Moves the filter wheel to selected position.                                                                                                                                                           | Science                                                      | Valid positions are 0 - 1103. Any value outside of the 3 - 1098 range will cause the physical limit switch to be hit by the filter wheel.                  | NIPREFWPOSNUM                                                               |
| 20            | NIINTWHLPOS  | Sets the internal software position of the filter wheel. This command does not physically move the filter wheel. It only sets the position where the software thinks the filter wheel is located.      | Science                                                      | Valid positions are 0 - 1103. The Built-In-Test (BIT) status of the filter wheel (NIFWBIT) must be "PASS" in order for the software to accept the command. | NIPREFWPOSNUM                                                               |

| Function Code | Command      | Description                                                                                                                                                                                                                                         | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                     | Telemetry for Commanded Value                                                                                            |
|---------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 21            | NIMEMWRTINIT | Initializes the parameters for software preparation for a memory data upload. Command includes number of bytes that will be written to memory and the address where they will be written.                                                           | Maint/Safe                                                   |                                                                                                                         |                                                                                                                          |
| 21            | NIFILWRTINIT | Initializes the parameters for software preparation for a file upload to memory. Command includes number of bytes that will be written to memory and the file name.                                                                                 | Maint/Safe                                                   |                                                                                                                         |                                                                                                                          |
| 21            | NITBLWRTINIT | Initializes the parameters for software preparation for a table upload to memory. Command includes number of bytes that will be written to memory, the table id number, and the offset from the start of the table where the data is to be written. | Maint/Safe                                                   |                                                                                                                         |                                                                                                                          |
| 22            | NIMEMWRITE   | Provides the data to be written into the memory. Data is written into a holding buffer.                                                                                                                                                             | Maint/Safe                                                   |                                                                                                                         |                                                                                                                          |
| 23            | NIMEMCHKSUM  | Provide the checksum for the data written by the memory write command.                                                                                                                                                                              | Maint/Safe                                                   | If the checksum does not match that which was uploaded, the command is rejected and data cannot be committed to memory. | The only telemetry verification that the checksum was validated is that the instrument accepted the NIMEMCHKSUM command. |

| Function Code | Command      | Description                                                                                                                              | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints                                                        | Telemetry for Commanded Value                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 24            | NICOMMIT     | Transfers the uplinked data contained in the holding buffer to the destination address specified in the Memory Write Initialize command. | Maint/Safe                                                               | The memory checksum must have been validated through the NIMEMCHKSUM command. | The only telemetry verification that the data was committed is that the instrument accepted the NIMEMCHKSUM command. You can also dump memory and verify it matches what was loaded.                                                                                                                                                                                                                                                          |
| 25            | NIMEMDUMP    | Performs a memory dump of the address specified.                                                                                         | all                                                                      |                                                                               | NIMDDW1-29 will contain memory dump data<br>NIMDADD will contain the start address of the dump.                                                                                                                                                                                                                                                                                                                                               |
| 25            | NITBLDUMP    | Performs a memory dump of the table specified.                                                                                           | all                                                                      |                                                                               | NIMEMDUMP00-79 will contain memory dump data. NIMDADD will contain the start address of the dump.                                                                                                                                                                                                                                                                                                                                             |
| 26            | NISHUTTERCAL | Starts calibration for the shutter specified.                                                                                            | all                                                                      |                                                                               | <p>NIPDCAL = "CALIBRATED"<br/> NIRC1CAL = "CALIBRATED"<br/> NIRC2CAL = "CALIBRATED"<br/> NIRC3CAL = "CALIBRATED"</p> <p>The software calibrates the shutters to the close position (position=2) which is reflected in the following telemetry:<br/> NIRC1PRESHPOSNUM<br/> NIRC2PRESHPOSNUM<br/> NIRC3PRESHPOSNUM<br/> NIPDPRESHPOSNUM</p> <p>Once calibrated the shutters will remain calibrated until power is cycled to the instrument.</p> |

| Function Code | Command | Description                                                                          | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints | Telemetry for Commanded Value                                                                                                                                                                                                                                |
|---------------|---------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 27            | NISETSF | Sets the scale factors for the heaters (RCs or HS) specified and the type specified. | Science                                                                  |                        | NIHSBNOMSF<br>NIHSMDACSF<br>NIHSDIFFMDSF<br>NIRC1BNOMSF<br>NIRC1MDACSF<br>NIRC1HTRSF<br>NIRC1DIFFMDSF<br>NIRC2BNOMSF<br>NIRC2MDACSF<br>NIRC2HTRSF<br>NIRC2DIFFMDSF<br>NIRC3BNOMSF<br>NIRC3MDACSF<br>NIRC3HTRSF<br>NIRC3DIFFMDSF                              |
| 28            | NIFWCAL | Starts calibration for the Filter Wheel                                              | all                                                                      |                        | NIFWCAL = "CALIBRATED"<br><br>The software calibrates the filter wheel to position=3 which is reflected in the following telemetry:<br>NIPREFWPOSNUM<br><br>Once calibrated the filter wheel will remain calibrated until power is cycled to the instrument. |

| Function Code | Command     | Description                                                                                                                                                                                                                                                    | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                | Telemetry for Commanded Value                                                                                                                                                                                                                               |
|---------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29            | NILDSWITCH  | Stops executing the current software load, loads up the latest software load on the modifiable EEPROM, and starts execution of the new load. User specifies whether the default tables or new tables are loaded.                                               | Maint/Safe                                                   |                                                    | After this command is sent the major frame counter (NIMJFRMCNT) will start counting by ones from zero.                                                                                                                                                      |
| 30            | NIDELTBL    | Erases the specified table(s) on the modifiable EEPROM such that only the default tables will be loaded on the next restart or load switch. This command will most likely be used when a complete new load is readied that has modified the size of its table. | Maint/Safe                                                   |                                                    |                                                                                                                                                                                                                                                             |
| 31            | NIAUTOCYCLE | This turns on and off the Automated Shutter Cycle Mode. This will start cycling the selected shutters open and closed for selected period until commanded off by this command, or until Maintenance/Safe mode becomes active.                                  | Science                                                      | The acceptable period range is 10 – 65535 seconds. | NIAUTOCYCLE<br>NIPDSHCYCLE<br>NIRC1SHCYCLE<br>NIRC2SHCYCLE<br>NIRC3SHCYCLE<br><br>All Activated shutters will close (position 2) when cycling starts and when it is stopped.<br>NIRC1PRESHP0SNUM<br>NIRC2PRESHP0SNUM<br>NIRC3PRESHP0SNUM<br>NIPDPRESHP0SNUM |

| Function Code | Command     | Description                                                                                                                                                                                                                                                                                                                                        | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                              | Telemetry for Command Value                                                                                                                                                              |
|---------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 32            | NIREFRESIST | Changes the reference of the resistance value for RC1, RC2, RC3, or HS based on PTC or HTR calibration. The user also inputs the resistor that is to be measured (External or Internal)                                                                                                                                                            | Science                                                      | If Maint/Safe mode becomes active, the resistance reference will be set to External for those motors that are set to Internal for PTC and Heater | If External is chosen:<br>1,6000 < NIHSPTCMRESAVG < 10,000<br>1,6000 < NIRC1-3PTCMRESAVG < 10,000<br><br>If Internal is chosen:<br>NIHSPTCMRESAVG ~ 20,000<br>NIRC1-3PTCMRESAVG ~ 10,000 |
| 33            | NIHSPRECHRG | Sets the HS precharge value for selected RC or PD.                                                                                                                                                                                                                                                                                                 | Science                                                      |                                                                                                                                                  | NIPDHSPRECHRG<br>NIRC1HSPRECHRG<br>NIRC2HSPRECHRG<br>NIRC3HSPRECHRG                                                                                                                      |
| 200           | NIDEACSEG   | This command will deactivate a portion of memory (by segment number) from being scrubbed by EDAC. To be sent when: upon examination of the error values, the EDAC appears to be broken, if there is a segment of memory for which the EDAC is not functioning properly, or some unforeseen event requires that the scrubber operations be altered. | All                                                          |                                                                                                                                                  |                                                                                                                                                                                          |



| Function Code | Command      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                                                      | Telemetry for Command Value                   |
|---------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| 201           | NIACSTEG     | This command will activate a portion of memory (by segment number) from being scrubbed by EDAC. To be sent when: upon examination of the error values, the EDAC appears to be broken, if there is a segment of memory for which the EDAC is not functioning properly, or some unforeseen event requires that the scrubber operations be altered. User inputs the start and finish address that will be associated with the segment number. | All                                                          |                                                                                                                                                                          |                                               |
| 202           | NICURTBLDUMP | This command will dump from RAM the current table by ID specified.                                                                                                                                                                                                                                                                                                                                                                         | All                                                          | Data will be downlinked in APID 90 and must be captured via sequential print. Schedule table slot 75, entry number 0 must be enabled in order for data to be downlinked. | NIMEMDUMP00-79 will contain memory dump data. |

| Function Code | Command    | Description                                                                                                                           | Instrument Mode (mnemonic NIINSTMODE) Where Command is Valid | Command Constraints                                                                                                                                                      | Telemetry for Command Value                   |
|---------------|------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| 202           | NIFILEDUMP | This command will dump from the boot, norm or temp disk the file name specified. It can also dump a directory listing of these disks. | All                                                          | Data will be downlinked in APID 90 and must be captured via sequential print. Schedule table slot 75, entry number 0 must be enabled in order for data to be downlinked. | NIMEMDUMP00-79 will contain memory dump data. |

| Function Code | Command     | Description                                                                                                                            | Instrument Mode<br>(mnemonic<br>NIINSTMODE)<br>Where Command<br>is Valid | Command<br>Constraints                                                                                                                                                   | Telemetry for Command Value                   |
|---------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| 202           | NIMEMDUMP90 | This command will dump memory from the boot, norm or temp disk from the address specified. It will dump the specified number of bytes. | All                                                                      | Data will be downlinked in APID 90 and must be captured via sequential print. Schedule table slot 75, entry number 0 must be enabled in order for data to be downlinked. | NIMEMDUMP00-79 will contain memory dump data. |

| OPs PROC (*.proc)  | ARGUMENTS                                                                                                                                                                                                                                                   | TIME (min.) | PROC CALLOUT(s) ( * if needed) | I&T PROC (*.proc) |                                                                                                                                                                                                  |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| nist_cmdcntr_reset | ---                                                                                                                                                                                                                                                         | < 1         |                                | nicmdcntreset     | <u>Reset NIS</u><br>Reset the counter for<br>It also clears<br><a href="#">[Ref. page 10]</a>                                                                                                    |
| nist_cntrl_loop    | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS, ALL</li> <li>• loop = OPEN, CLOSE</li> </ul>                                                                                                                                           | 1           |                                | nitempctrl        | <u>Set NIST</u><br>Sets the control NIS<br>Mode prior to<br><a href="#">[Ref. page 10]</a>                                                                                                       |
| nist_diff_mode     | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3</li> <li>• type = ABSOLUTE, RC1, RC2, RC3, HS</li> </ul>                                                                                                                                    | 1           |                                | nidiffmodectrl    | <u>NISTAR D</u><br>Selects the selected F<br>controlled i<br>(Closed Lo<br>to RC1, RC<br>NISTAR s<br><br>The differ<br>actively co<br>servo loop<br>fixed abso<br><a href="#">[Ref. page 10]</a> |
| nist_edacseg_act   | <ul style="list-style-type: none"> <li>• seg = EDAC Segment (0-9)</li> <li>• start_addr = Start address of location to be scrubbed (Hex)<br/>Example: 0xfa34</li> <li>• stop_addr = End address where scrub will stop (Hex)<br/>Example: 0x20ba4</li> </ul> | 1           |                                | niactseg          | <u>Activate M</u><br>Creates an<br>memory se<br>Segment 9<br>set and ac<br><br>Segment (0<br>0x7FFFFFFF<br>reserved f<br>disable me<br>of Segmer<br>segments.<br><a href="#">[Ref. page 10]</a>  |
| nist_edacseg_deact | seg = EDAC Segment (0-9)                                                                                                                                                                                                                                    | 1           |                                | nideacseg         | <u>Deactivate</u><br>Deactivate<br>segment in<br>(Segment<br>ranges ma<br><a href="#">[Ref. page 10]</a>                                                                                         |

|                    |                                                                                                                                                                                                                                                   | (min.) |                                                                                                                                                         | (.proc)                                                                                 |                                                                                                                                                                                                                                          |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| nist_file_dump     | <ul style="list-style-type: none"> <li>• nist_dir = BOOT, NORM, TEMP, DIR_BOOT*, DIR_NORM*, DIR_TEMP*</li> <li>• filename = Name of file to be dumped*</li> </ul> <p><b>*NOTE:</b><br/>Filename (2nd arg.) NOT needed for directory listings.</p> | varies |                                                                                                                                                         | <ul style="list-style-type: none"> <li>• nifiledump</li> <li>• nidirdump</li> </ul>     | <p>NISTAR F<br/>Downlinks<br/>directory c<br/>utility com<br/>to the grou</p> <p><a href="#">[Ref. page</a></p>                                                                                                                          |
| nist_func_htrcal   | ---                                                                                                                                                                                                                                               | 13     | <ul style="list-style-type: none"> <li>• NIST_MODE ("SCIENCE") *</li> <li>• NIST_CMDCNTR_RESET *</li> </ul>                                             | <ul style="list-style-type: none"> <li>• nistar_1_2</li> <li>• nist_func_1_2</li> </ul> | <p>NISTAR A<br/>Verification<br/>Procedure<br/>Digital Cor<br/>and heate<br/>Sink (HS).</p> <p>The calibr<br/>After each<br/>(BNOM), t<br/>Heater Sc<br/>values, aft<br/>no change</p> <p><a href="#">[Ref. page</a></p>                 |
| nist_func_openloop | ---                                                                                                                                                                                                                                               | 7      | <ul style="list-style-type: none"> <li>• NIST_MODE ("SCIENCE") *</li> <li>• NIST_CNTRL_LOOP("ALL", "OPEN") *</li> <li>• NIST_CMDCNTR_RESET *</li> </ul> | <ul style="list-style-type: none"> <li>• nistar_1_6</li> <li>• nist_func_1_6</li> </ul> | <p>NISTAR C<br/>Performs f<br/>via Open l</p> <p>Procedure<br/>Sink (HS)<br/>powers an<br/>Plots of th<br/>Resistance<br/>increase.</p> <p>The open<br/>default val</p> <p><a href="#">[Ref. page</a></p> <p>Default op<br/>RC1, RC2</p> |

|                     |     | (min.) |                                                                                                                                                                                                                         | (.proc)                                                                                 |                                                                                                                                                                                                                                                          |
|---------------------|-----|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| nist_func_pdcircuit | --- | 3      | <ul style="list-style-type: none"> <li>• NIST_MODE ("SCIENCE") *</li> <li>• NIST_SHUTR_CAL("SD") *</li> <li>• NIST_SHUTR_MOVE("SD", 2)</li> <li>• NIST_SHUTR_MOVE("SD", 198)</li> <li>• NIST_CMDCNTR_RESET *</li> </ul> | <ul style="list-style-type: none"> <li>• nistar_1_8</li> <li>• nist_func_1_8</li> </ul> | <p><u>NISTAR P</u><br/>The Silicon<br/>open posit<br/>for 30 sec.<br/>position. -<br/>data is ag</p> <p>Data shou<br/>opened ar</p> <p><u>NOTE:</u> NI<br/>thi:</p>                                                                                      |
| nist_func_shutrfw   | --- | 4      | <ul style="list-style-type: none"> <li>• NIST_MODE ("SCIENCE") *</li> <li>• NIST_SHUTR_CAL("ALL")</li> <li>• NIST_FW_CAL</li> <li>• NIST_CMDCNTR_RESET *</li> </ul>                                                     | <ul style="list-style-type: none"> <li>• nistar_1_3</li> <li>• nist_func_1_3</li> </ul> | <p><u>NISTAR S</u><br/>Performs 1<br/>shutters fc<br/>Photodiod<br/>Wheel (FV</p> <p>The shutte<br/>moved bef<br/>range of r<br/>and count<br/>motion.</p> <p><u>NOTE:</u><br/>To preven<br/>Photodiod<br/>spacecraft<br/><a href="#">[Ref. page</a></p> |
| nist_fw_cal         | --- | 1      | NIST_CMDCNTR_RESET *                                                                                                                                                                                                    | nicalfw                                                                                 | <p><u>NISTAR F</u><br/>Calibrates<br/>powered b<br/>in order to<br/>completes</p> <p>FW positic<br/>R<br/>R<br/>R<br/>S<br/><a href="#">[Ref. page</a></p>                                                                                               |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | (min.) |  | (.proc)   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| nist_fw_move | <p>step_num = FW Stepper<br/>Motor Position<br/>(range: 0 to 1103)</p> <p>= 3 (Optical Position 1,<br/>Start)</p> <p>= 102 (Optical Position 12)</p> <p>= 202 (Optical Position 11)</p> <p>= 302 (Optical Position 10)</p> <p>= 402 (Optical Position 9)</p> <p>= 502 (Optical Position 8)</p> <p>= 602 (Optical Position 7)</p> <p>= 702 (Optical Position 6)</p> <p>= 802 (Optical Position 5)</p> <p>= 902 (Optical Position 4)</p> <p>= 1002 (Optical Position 3)</p> <p>= 1101 (Optical Position 2,<br/>End)</p> | 1      |  | nimvwheel | <p>Set NISTAR<br/>Moves NISTAR<br/>position. The<br/>optical position<br/>holding two<br/>with filters<br/>locations to</p> <p>The FW motor<br/>direction, and<br/>starting or<br/>toward the<br/>direction, 1<br/>position 3.</p> <p>The filter wheel<br/>positions (from<br/>being in the<br/>direction. The<br/>hit during the<br/>automatic<br/>switch was<br/>position 1<br/>lifetime limit</p> <p>NOTE:<br/>NISTAR motor<br/>prior to motor<br/><a href="#">[Ref. page</a></p> |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (min.) |                                                                                                             | (.proc)    |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| nist_htr_cals   | <ul style="list-style-type: none"> <li>• cal_type = PTC, HTR, ALL</li> <li>• device = RC1, RC2, RC3, HS</li> </ul> <p><u>ARGUMENT NOTES:</u></p> <ul style="list-style-type: none"> <li>• cal_type = "ALL" performs calibrations on all RCs and HS.</li> <li>• Heater (HTR) calibration is not valid for device = HS.</li> <li>• ADC calibration is not a calibration type option since it will execute all calibration procedures on all devices (same as "ALL" option).</li> </ul> | 6      | <ul style="list-style-type: none"> <li>• NIST_MODE ("SCIENCE") *</li> <li>• NIST_CMDCNTR_RESET *</li> </ul> | nistartcal | <p>NISTAR A<br/>Performs a<br/>Positive Temperature<br/>NISTAR R<br/>heater calibration<br/>selected for</p> <p>The ADC calibration<br/>internal calibration<br/>bridge error<br/>sensor resistance<br/>an internal</p> <p>The PTC calibration<br/>the temperature<br/>activated voltage<br/>resistor in<br/>then adjust<br/>errors.</p> <p>The ADC, RCs and<br/>all RCs and<br/>power cycle<br/>starting the<br/><a href="#">[Ref. page 10]</a></p> |
| nist_htr_sf     | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS</li> <li>• sf_type = BNOMSF, MDACSF, HTRSF, DIFFMODESF</li> <li>• sf_value = Scale Factor Value</li> </ul> <p><u>NOTE:</u> Heater scale factor (HTRSF) type not valid for Heat Sink (HS).</p>                                                                                                                                                                                                                    | 1      |                                                                                                             | nisetsf    | <p>NISTAR H<br/>Sets the heater<br/>(RC) or Heat Sink<br/>following:<br/>Digital to Analog<br/>Mode.</p> <p>NISTAR sets<br/>factors.<br/><a href="#">[Ref. page 10]</a></p>                                                                                                                                                                                                                                                                          |
| nist_mem_commit | <p>destination = BEEPROM*, EEPROM*, RAM</p> <p>* NOTE: Instrument Mngr &amp; NISTAR PDL approval required.</p>                                                                                                                                                                                                                                                                                                                                                                       | varies |                                                                                                             | nicommit   | <p>NISTAR M<br/>Writes the<br/>to the specified<br/>EEPROM, use data<br/>the Boot or<br/>NISTAR is<br/>is copied to</p> <p>Caution should<br/>EEPROM<br/>Instrument<br/>the Boot/Cal</p>                                                                                                                                                                                                                                                             |



|                     |                                                                                                                                                                                                                                                                                        | (min.) |  | (.proc)                                                                               |                                                                                                                                                                                               |
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|                     |                                                                                                                                                                                                                                                                                        |        |  |                                                                                       | memory c                                                                                                                                                                                      |
| nist_mem_dump       | <ul style="list-style-type: none"> <li>• start_addr = Start address of location to be dumped (Hex)<br/>Example: 0xfa34</li> <li>• apid = APID_86*, APID_90</li> <li>• num_bytes* = Number of bytes to be dumped</li> </ul> <p>* Number of bytes NOT needed if dumping via APID 86.</p> | varies |  | <ul style="list-style-type: none"> <li>• nimemdump</li> <li>• nimemdump_90</li> </ul> | <p><u>NISTAR M</u><br/>Performs a<br/>RAM addr<br/>APID 86 o</p> <p>APID 86 d<br/>regularly c<br/>by the Cor<br/>is then col<br/>be used to<br/>ground.</p> <p><a href="#">[Ref. page</a></p> |
| nist_memdump_byaddr | <ul style="list-style-type: none"> <li>• start_addr = Start address of location to be dumped (Hex)<br/>Example: 0xfa34</li> <li>• stop_addr = Stop address where dump will be stopped (Hex)<br/>Example: 0x20ba4</li> </ul>                                                            |        |  |                                                                                       | <p>Performs a<br/>RAM addr<br/>CompHub<br/>ground via<br/>NISTAR n</p> <p>The memc<br/>time so m<br/>address r<br/>of 65535 t</p>                                                             |

|                             |     | (min.) |                            | (%.proc) |                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------|-----|--------|----------------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| nist_memload_booteepro<br>m | --- | varies | NIST_MEM_COMMIT("BEEPROM") |          | <p>Memory U<br/>Uplinks a l<br/>directive th<br/>The file for</p> <p>The uplink<br/>RAD6000<br/>the uplink<br/>checksum<br/>match and<br/>"NICOMM<br/>holding bu<br/>EEPROM.<br/>to write the</p> <p>Caution sh<br/>EEPROM.<br/>and will ta<br/>NISTAR F<br/>table or m<br/>"nist_merr</p> <p>Estimated<br/>- Comple<br/>- Applicat<br/>- Table re</p> <p>NOTE: N<br/>memory ci</p> |

|                     |     | (min.) |                           | (%.proc) |                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------|-----|--------|---------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| nist_memload_eeprom | --- | varies | NIST_MEM_COMMIT("EEPROM") |          | <p>Memory U<br/>EEPROM<br/>Uplinks a l<br/>directive th<br/>EEPROM.</p> <p>The uplink<br/>RAD6000<br/>the uplink<br/>checksum<br/>match and<br/>"NICOMM<br/>holding bu<br/>EEPROM.<br/>to write th</p> <p>Caution sh<br/>Modifiable<br/>EEPROM<br/>is cycled.<br/>uplink and<br/>RAM, via :</p> <p>Estimated<br/>- Comple<br/>- Applicat<br/>- Table re</p> <p>NOTE: N<br/>memory c</p> |

|                  |                            | (min.) |                         | (%.proc)   |                                                                                                                                                                                                                                                                                                                        |
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| nist_memload_ram | ---                        | varies | NIST_MEM_COMMIT("RAM")  |            | <p>Memory Uplinks a directive th uplink sho</p> <p>The uplink RAD6000 the uplink checksum match and "NICOMM holding bu EEPROM. to write the</p> <p>NISTAR F RAM; how NISTAR p EEPROM is cycled. commit the EEPROM, required p</p> <p>Estimated<br/>- Complet<br/>- Applicat<br/>- Table re</p> <p>NOTE: N memory c</p> |
| nist_mode        | instr_mode = SAFE, SCIENCE | < 1    | NIST_MODE_CMD ("ARM") * | niinstmode | <p>NISTAR F<br/>This proce<br/>Mode or M</p> <p>Proc chec<br/>FSW mod<br/>order to se<br/>disarmed,<br/>Mode and</p> <p>The estim<br/>"science d<br/>fully functi<br/>proc checl<br/>temperatu<br/>Mode.</p>                                                                                                           |

|                    |                                                                                                                                                                                                                                          | (min.) |  | (.proc)                                                                                                              |                                                                                                                          |
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| nist_mode_cmd      | cmd_mode = ARM, DISARM                                                                                                                                                                                                                   | < 1    |  | nimodecmd                                                                                                            | <p>Arm/Disarm Arms or disarm command Science Mission command Maintenance</p> <p>After an arm transition mode command</p> |
| nist_noop          | ---                                                                                                                                                                                                                                      | < 1    |  | ninoop                                                                                                               | <p>NISTAR N</p> <p>This procedure There should be sending the should include</p> <p><a href="#">[Ref. page</a></p>       |
| nist_openloop_pwr  | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS</li> <li>• opnlp_pwr = Desired Open Loop Power Value (Watts)</li> </ul> <p><u>Valid Ranges for opnlp_pwr:</u><br/> RC1, RC2, RC3: 0 - 0.00005 W<br/> HS: 0 - 3 W</p> | < 1    |  | niopnlppwr                                                                                                           | <p>Set NISTAR Sets the N open loop NISTAR s</p> <p><a href="#">[Ref. page</a></p> <p>Default op RC1, RC2</p>             |
| nist_pid_tuning    | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS, PD</li> <li>• pid = P, I, D, K</li> <li>• value = Tuning Parameter Value (-3.403E+38 to +3.403E+38)</li> </ul>                                                      | 1      |  | <ul style="list-style-type: none"> <li>• nipid2d</li> <li>• nipid2i</li> <li>• nipid2k</li> <li>• nipid2p</li> </ul> | <p>Set NISTAR Sets the N Integral De (RC1, RC2 parameter</p> <p>NOTE: NI</p> <p><a href="#">[Ref. page</a></p>           |
| nist_prechrg_fixed | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3</li> <li>• type = OPEN, CLOSE</li> <li>• fltr = Filter Type (A, B, C)</li> <li>• setpt = Precharge Setpt Value</li> </ul>                                                | 1      |  | <ul style="list-style-type: none"> <li>• nifixopen</li> <li>• nifixclose</li> </ul>                                  | <p>NISTAR F</p> <p>Sets the filter algorithm for NISTAR s</p> <p><a href="#">[Ref. page</a></p>                          |

|                   |                                                                                                                                       | (min.) |                                                                                                                            | (.proc)                                                                                                                                             |                                                                                                                                                |
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| nist_prechrg_hs   | <ul style="list-style-type: none"> <li>• chan = RC1, RC2, RC3, PD</li> <li>• setpt = HS Precharge Value</li> </ul>                    | < 1    |                                                                                                                            | nihsprech                                                                                                                                           | <u>NISTAR H</u><br>Sets the H<br>Receiver C<br>NISTAR s<br><a href="#">[Ref. page</a>                                                          |
| nist_prechrg_mode | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS</li> <li>• type = FIXED, AUTO, OFF</li> </ul>                     | < 1    |                                                                                                                            | niprechmod                                                                                                                                          | <u>NISTAR P</u><br>Sets the N<br>the autom.<br>the specifi<br>should be<br><a href="#">[Ref. page</a>                                          |
| nist_ptc_resist   | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS</li> <li>• setpt = PTC Resistance<br/>Setpoint in Ohms</li> </ul> | 1      |                                                                                                                            | niptcresist                                                                                                                                         | <u>NISTAR P</u><br>Sets the P<br>(temperatu<br>should be<br><a href="#">[Ref. page</a>                                                         |
| nist_pwr_off      | ---                                                                                                                                   | 1      | <ul style="list-style-type: none"> <li>• NIST_SHUTR_AUTOCYCLE ("OFF")</li> <li>* </li> <li>• NIST_MODE ("SAFE")</li> </ul> | <ul style="list-style-type: none"> <li>• nipwrdwn</li> <li>• nist_pwr_onoff ("off")</li> <li>• nist_pwr("off")</li> </ul>                           | <u>NISTAR P</u><br>This proce<br>NISTAR, t<br>1) Shuttl<br>which<br>RC3,<br>2) NIST<br>Main<br>close<br>its ho<br><a href="#">[Ref. page</a>   |
| nist_pwr_on       | ---                                                                                                                                   | 1      |                                                                                                                            | <ul style="list-style-type: none"> <li>• nipwrup</li> <li>• nist_pwr_onoff ("on")</li> <li>• nist_pwr("on")</li> <li>• nist_pwr("on_pn")</li> </ul> | <u>NISTAR P</u><br>Powers NI<br>radiomete<br>at or abov<br><br><u>NOTE:</u> If<br>(Ul<br>ter<br>SII<br>dis<br>he<br><a href="#">[Ref. page</a> |

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | (min.) |                      | (.proc)     |                                                                                                                                                                                                                                                                                 |
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| nist_ref_resist      | <ul style="list-style-type: none"> <li>• chan = RC1, RC2, RC3, HS*</li> <li>• src = PTC, HEATER*</li> <li>• resist = INTERNAL, EXTERNAL</li> </ul> <p>*NOTE: HS channel is not valid if HEATER is the source.</p>                                                                                                                                                                                                                                                                                       |        |                      | nirefresist | <p>NISTAR R</p> <p>Sets the re selected c Coefficient Mode.</p> <p>[Ref. page</p>                                                                                                                                                                                               |
| nist_shutr_autocycle | <ul style="list-style-type: none"> <li>• cycl_state = ON, OFF*</li> <li>• rc1_state = 0 (inactive)<br/>= 1 (active)</li> <li>• rc2_state = 0 (inactive)<br/>= 1 (active)</li> <li>• rc3_state = 0 (inactive)<br/>= 1 (active)</li> <li>• pd_state = 0 (inactive)<br/>= 1 (active)</li> <li>• cycl_time = # sec or min per cycle (10 - 65535 sec)<br/>or (1 - 32767 min)</li> <li>• time_unit = cycle time unit (SEC, MIN)</li> </ul> <p>* NOTE: If state = OFF, no additional arguments are needed.</p> | 1      |                      | niautocycle | <p>NISTAR A</p> <p>Turns auto shutter(s). the select auto-cycle entered.</p> <p>Shutter cy example, i for 150 se is repeate shutters w stopped.</p> <p>NOTE:<br/>Proc will E<br/>1) NIST/<br/>shutte<br/>autoc<br/>2) To pr<br/>shutte<br/>thrus<br/>enab</p> <p>[Ref. page</p> |
| nist_shutr_cal       | shutter = RC1, RC2, RC3, SD, ALL                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2      | NIST_CMDCNTR_RESET * | nicalshut   | <p>NISTAR S</p> <p>Calibrates is powered RC2, RC3 should be</p> <p>The select detector (p position (p 25,000 hit</p>                                                                                                                                                            |

|                 |                                                                                                                                                                                                                                                                       | (min.) |  | (.proc)                                                                                                 |                                                                                                                                                                                                                                                                                                                                         |
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| nist_shutr_move | <ul style="list-style-type: none"> <li>• shutr = RC1, RC2, RC3, SD, ALL_CLOSE*, ALL_OPEN*</li> <li>• pos_num = 0 to 200<br/>= 2 (closed)<br/>= 198 (open)</li> </ul> <p>* NOTE:<br/>Position number (2nd arg.), not needed for shutr = "ALL_OPEN" or "ALL_CLOSE".</p> | 1      |  | <ul style="list-style-type: none"> <li>• nicloshut</li> <li>• nimvshut</li> <li>• niopenshut</li> </ul> | <p>Set NISTAR<br/>Moves NISTAR<br/>Photodiode<br/>OPEN shut<br/>CLOSED  <br/>position ra</p> <p>Each shut<br/>software s<br/>place to ke<br/>mechanica<br/>detector is<br/>automatic<br/>0) limit sw<br/>"open" (po</p> <p>NOTE:<br/>1. NISTAR<br/>must be<br/>2. To prev<br/>shutter<br/>thruste</p> <p><a href="#">[Ref. page</a></p> |
| nist_sine_freq  | <ul style="list-style-type: none"> <li>• device = RC1, RC2, RC3, HS</li> <li>• freq = 35 - 155 Hz</li> </ul>                                                                                                                                                          | 1      |  | nisinwvfreq                                                                                             | <p>NISTAR S<br/>Sets the s<br/>(RC) or He</p> <p>The excita<br/>initializatio<br/>sine wave<br/>10 kHz. Ea<br/>within a ra</p> <p><a href="#">[Ref. page</a></p>                                                                                                                                                                        |



|                 |                                                                                                                                                                                                                                                                                                                                                                             | (min.) |  | (.proc)                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                  |
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| nist_tbl_dump   | <ul style="list-style-type: none"> <li>tbl_id = NISTAR table to be dumped (0 - 25, 99)</li> <li>apid = APID to use for downlinking of table dump data (APID_86, APID_90*)</li> <li>offset* = # bytes from the start of the table to begin dumping from (offset is by # of data words)</li> </ul> <p><u>*NOTE:</u> Offset argument is not needed if dumping via APID 90.</p> |        |  | <ul style="list-style-type: none"> <li>nitbldump</li> <li>nicurtbldump</li> <li>nicurtbldump_all</li> </ul> | <p>NISTAR T<br/>Dumps a s<br/>RAM. Two<br/>NITBLDUI</p> <p>NITBLDUI<br/>EEPROM<br/>identificati<br/>which is th<br/>dump will<br/>field to zer</p> <p>NICURTB<br/>required fi<br/>dumped.</p> <p>The dump<br/>APID 90.<br/>NITBLDUI<br/>90 only do<br/>APID 86, c<br/>through re</p> <p>A table du<br/>only dump<br/>APID 90 u<br/>then collec<br/>be used to<br/><a href="#">[Ref. page</a></p> |
| nist_verify_hk  | ---                                                                                                                                                                                                                                                                                                                                                                         | < 1    |  | <ul style="list-style-type: none"> <li>nistar_1_1</li> <li>nist_func_1_1</li> </ul>                         | <p>NISTAR H<br/>Procedure<br/>are within<br/>in order to</p> <p>The NIST/<br/>This is the<br/>motors cal<br/>The lower<br/>Aerospace<br/><a href="#">[Ref. page</a></p>                                                                                                                                                                                                                          |
| nist_verify_ptc | ---                                                                                                                                                                                                                                                                                                                                                                         | 2      |  | <ul style="list-style-type: none"> <li>nistar_1_5</li> <li>nist_func_1_5</li> </ul>                         | <p>NISTAR P<br/>Verifies th<br/>(RC) Posit<br/>Resistance</p>                                                                                                                                                                                                                                                                                                                                    |

| Flight Operation Procedure            | Description                                        |
|---------------------------------------|----------------------------------------------------|
| INST_NISTAR Intercomparison Cal       | Details of procedures for intercomparison, and for |
| INST_NISTAR Dark Cal                  | Details of procedures for                          |
| INST_NISTAR Power On with Contingency | Details of procedures for                          |